



Liner System Installation Construction Quality Assurance/Quality Control Plan (CQA/QCP)

**Eckles Road Site
Livonia, Michigan**

RACER Trust

September 03, 2021

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1. Introduction

1.1 Purpose of this Report

This Construction Quality Assurance/Quality Control Plan (CQA/QCP) is for impermeable cover system installation at the 13000 Eckles Road Site in Livonia, Michigan, and was prepared by GHD Services Inc. (GHD), on behalf of RACER Trust. This CQA/QCP describes the planned and systemic activities that will be used to verify that installation of the impermeable cover system satisfies the construction drawings and specifications requirements

The remainder of this section describes the project background and the purpose of the CQA/CQP.

1.2 Background Information

Background information for the 13000 Eckles Road Site in Livonia, Michigan is provided in the “Revised Interim Measure Work Plan, Area 1 – Former Plating Area, Eckles Road Site, Livonia, Michigan”, dated July 20, 2021.

1.3 Purpose and Organization of Report

This CQA/QCP presents the construction quality assurance/quality control (CQA/QC) procedures to be implemented during construction of the impermeable cover system for the Site to ensure that the construction activities meet or exceed all design criteria, drawings, and specifications. This report is organized as follows:

Section 1.0 – Presents the background information, purpose, and organization of the report.

Section 2.0 – Provides a description of the remedial action (RA) activities.

Section 3.0 – Outlines the project organization and responsibilities.

Section 4.0 – Presents the personnel qualification requirements.

Section 5.0 – Presents the project meeting requirements.

Section 6.0 – Describes the inspection and testing activities required to ensure that construction and materials comply with all design specifications and plans.

Section 7.0 – Describes documentation requirements of construction quality assurance (CQA) activities.

Construction quality control (CQC) activities are procedures to be implemented by the selected contractor to measure and control the characteristics of the materials and the construction methods during remedial action (RA) activities to demonstrate that the materials and construction meet the requirements of the design specifications and drawings. CQC activities to be implemented by the contractor during the RA activities are identified in the individual specification sections provided in the Project Specifications (see Appendix A). The Design Drawings are provided in Appendix B.

The Owner’s Representative will provide construction management and associated independent Construction Quality Assurance (CQA). As an integral part of the CQA program, the Owner’s Representative will review all the Contractor’s CQC data, and in addition, will perform additional tests independently of the Contractor’s testing.

2. Project Organization

2.1 Construction Quality Assurance and Quality Control Organization

The responsibility and lines of authority and communications will be described in this section. Each organization involved in the RA construction activities is identified, followed by a description of the roles and responsibilities of the organization and the roles and responsibilities of key individuals within each organization. These individuals are to be identified either identified by name or title. This section will also identify the lines of authority and the flow of information within CQA/QC Team.

2.2 Roles and Responsibilities

A brief description of the CQA/QC duties of the key personnel are presented below.

2.3 Project Manager

The duties of the Project Manager are as follows:

- i. Provide overall construction project oversight.
- ii. Ensure all resources are available on an as-required basis.
- iii. Participate in key technical discussions with the Owner and/or their Representative, and the Contractor.
- iv. Participate in Pre-Final and Final Inspections.

2.4 Project Coordinator

The duties of the Project Coordinator are as follows:

- i. Provide day-to-day construction project management.
- ii. Provide managerial guidance and technical support to the Owner's Representative.
- iii. Provide technical representation at project meetings as appropriate.
- iv. Prepare and review construction documentation and reports.
- v. Review and approve all technical submittals and shop drawings.
- vi. Recommend design changes, if required.
- vii. Conduct occasional Site visits to confirm the RA activities are being implemented in accordance with the intent of the remedial design (RD).
- viii. Liaise frequently with the Owner's Representative.
- ix. Enforce overall compliance with construction contractor's implementation of the RA.
- x. Review the Remedial Design (RD) to confirm the RA was properly implemented.
- xi. Prepare the Final Engineering Report.
- xii. Participate in Pre-Final and Final Inspections.

2.5 Owner's Representative

The duties of the Owner's Representative are as follows:

- i. Reports to Project Coordinator.

- ii. Provide immediate oversight of all on-Site project activities.
- iii. Provide field management of CQA/QC activities.
- iv. Conduct CQA inspections as indicated in this CQA/QCP.
- v. Ensure performance of appropriate field testing.
- vi. Ensure that regular calibration of testing equipment is conducted and recorded.
- vii. Ensure that all Site activities are recorded daily and maintained, including a photo log.
- viii. Ensure that CQA/QC test results are accurately recorded.
- ix. Review the Contractor's CQC data.
- x. Perform data validation and assessment.
- xi. Coordinate with CQA Services Laboratory to conduct CQA tests
- xii. Immediately notify Project Coordinator whether test results comply with design specifications.
- xiii. Identify work that should be accepted, rejected, or uncovered for observation, or that may require special testing, inspection, or approval.
- xiv. Reject defective work and verify that corrective measures are implemented.
- xv. Advise on data corrective action procedures.
- xvi. Interact daily with the Contractor to provide assistance in modifying the materials and work to comply with the specified design.
- xvii. Enforce construction contract in the field.
- xviii. Review construction activities and completed works against drawings and specifications.
- xix. Monitor and record the Contractor's CQC activities and collect copies of CQC data.
- xx. Prepare CQA/QC representation of project activities.
- xxi. Participate in Pre-Final and Final Inspections.
- xxii. Prepare and review reports.

The individual designated to be the Owner's Representative will be Scott Sholar of GHD, with assistance from other trained GHD staff as required.

2.6 CQA Services Laboratory

CQA Services Laboratory that will conduct CQA tests will be TRI Environmental. The duties of the CQA Services Laboratory are to provide CQA testing of materials used in the construction activities, as requested by the Owner's Representative, to confirm construction activities have been implemented according to the construction specifications and drawings.

2.7 Contractor (AEG)

The duties of the Contractor, as they relate to CQA/QC, are as follows:

- i. Implement the RA CQC requirements specified in the project specifications.
- ii. Submit samples and/or materials for testing to determine if samples/materials meet specified requirements.
- iii. Submit manufacturer's material properties data and QC certificates to the Owner's Representative.
- iv. Provide quality materials and workmanship to ensure that materials meet project specifications.
- v. Record daily CQC activities in the Contractor's Site log book and submits a "Daily Construction Quality Control Report" to the Owner's Representative.
- vi. Carry out construction activities according to project specifications and design drawings.

- vii. Develop and implement a Site-specific Health and Safety Plan (HASP), including applicable Covid-19 site-specific protocols and safety documentation.
- viii. Document the labor, materials and equipment utilized during construction activities and submit this information on the Contractor's work summary sheets to the Owner's Representative.
- ix. Conduct CQC tests and inspections as indicated in the specifications, including maintenance of testing equipment in good working order, and calibrated as required
- x. Ensure that CQC test results and inspections are accurately recorded; and that the Owner's Representative is immediately notified whether test results comply with the specifications.
- xi. Submit all CQC data to Owner's Representative for review.
- xii. Maintain copies of applicable referenced standards.

3. Participate in Pre-Final and Final Inspection and Testing Activities

3.1 Inspections

Throughout the period of construction, the quality of work completed and material used for each of the work tasks will be confirmed through regular inspections of the work. Regular inspections will be completed throughout the construction by the Owner's Representative on a periodic basis, as required.

In general, inspections to be conducted by the Owner's Representative include the following:

- i. The Site will be inspected prior to construction, during construction and after construction activities are complete to determine whether any damage occurs as a result of construction activities. The inspection will consist of the following:
 - Walking the Site and visibly identifying any significant cracks, ruts, and other deficiencies in the subgrade and ensuring these are corrected as appropriate to ensure the integrity of the subsequently placed geomembrane. In locations where subgrade cannot be cleaned up appropriately, a layer of geotextile will be placed prior to geomembrane installation.
 - Subsequent to completion of RA construction activities, the pre-construction, interim and post-construction inspections will be evaluated by the Owner's Representative, in consultation with the Owner, to determine if any noted damage to the Site occurred as a result of RA construction activities.
- ii. Daily inspections of the work in progress.
- iii. Inspection of material as it is delivered to the Site to check for damage during delivery.
- iv. Comparison of the material delivered to the Site to the design specifications to ensure that the proper material has been delivered to the Site.
- v. Inspections of materials after they have been installed to ensure that there has not been damage during installation and that the materials have been installed in accordance with the construction specifications.
- vi. A pre-construction inspection will be performed prior to beginning work on any major work task. A pre-construction inspection will include the following:
 - A review of contract and specification requirements to ensure that all materials and/or equipment have been tested according to applicable standards and specifications.
 - Ensure that provisions have been made to provide required quality control testing.
 - Examination of the work area to ascertain that all applicable/necessary preliminary work tasks have been completed/performed.

- vii. General inspections will be performed periodically as the amount of work completed warrants an inspection. A general inspection will include the following:
 - Examination of the quality of workmanship.
 - Testing of materials for compliance with the project specifications/requirements.
 - Identification of any omissions.
 - General progress of work performed.
- viii. Pre-final/final inspections will be performed upon completion of the RA work to ensure/verify compliance with the project specifications and drawings and to ensure that deficiencies identified in the general inspections have been corrected.

The identified inspections will be performed by the Owner's Representative and the results of the inspections will be recorded in the daily Site log book as described in Section 7.0. Copies of the pre-construction, general and pre-final/final inspection reports will be provided to the Owner's Representative, the Owner, and all parties involved in the inspection, as appropriate.

The components of each work task to be inspected, the types of inspections required, and the frequency of the inspections are summarized in Table 3.1.

3.2 Testing

In addition to the daily inspections of the construction progress, material testing will be carried out as required by the specifications. Material testing will be performed to ensure compliance with manufacturer specifications and design criteria as presented in the project specifications.

Testing requirements, methods of testing, testing frequency, key acceptance criteria, test sample sizes and locations, and potential corrective measures for each of these work task components and required submittals (i.e., test reports, certificates verifying material quality/workmanship, etc.) are summarized in Table 3.2. If a particular test for a contractor material or work activity frequently fails, the Owner's Representative will increase the rate of CQA testing as determined appropriate.

RA CQC testing will be performed by the contractor to measure and control the characteristics of the materials and installation procedures used in the RA activities to demonstrate that the materials and installations meet the requirements of the project specifications. Details of the RA CQC requirements are specified in the project specifications.

4. Inspection Documentation

4.1 General

This section details the documentation requirements for the CQA/QCP. The proper, thorough, and accurate documentation of all CQA Site activities is important in ensuring quality installation. CQA testing will be documented daily.

4.2 Daily Site Log Book

The Owner's Representative will record daily construction quality control activities in a Daily Site Log Book to be kept on Site at all times. The log book will include the following information:

- i. Date, weather conditions.
- ii. Personnel on Site.

- iii. Description of all Site activities.
- iv. Decisions made regarding approval of units of material or of work, and/or corrective actions to be taken in cases of substandard quality.
- v. Submittals made by suppliers verifying material quality.
- vi. Construction delays, and causes.
- vii. Areas affected by delays.
- viii. Construction problems and corrective actions.
- ix. Present phase of construction.
- x. Material and/or equipment delivered to Site (including equipment demobilization).
- xi. Inspections made.
- xii. Health and safety considerations, including applicable Covid-19 site-specific protocols and safety documentation.
- xiii. Quality control tests performed, and results of tests taken on previous workday.
- xiv. Changed conditions/conflicts encountered.
- xv. Remarks.

Each daily entry into the log will be signed by the Owner's Representative as verification to its correctness. An example of this Daily Observation Report is presented in Appendix C.

4.3 Daily Photo Documentation

As part of the daily log documentation, digital photographs will be taken, and date stamped showing significant construction activities. The daily photo log will be maintained by the Owner's Representative and will include representative photos of that day's activities. The photographs will be attached to the Daily Observation Report.

4.4 CQC Instrument Calibration

Owner's Representative will record calibrations and re-calibrations of test equipment by Contractor (liner installer) in the Daily Site Log Book, maintained on Site by the Owner's Representative. Actions taken as a result of recalibration will be recorded, as described in the next section.

4.5 CQC Inspection Log Book

All observations and results of CQC field tests will be recorded by the Owner's Representative on field record forms (see Appendix D). These forms will be kept on Site and maintained by the Owner's Representative. Results of the CQC inspections and field tests will be summarized in the Daily Site Log Book. The Daily Site Log Book will include the following information:

- i. Date, time, weather conditions.
- ii. Description or title of the inspection or test activity.
- iii. Location of the inspection or test activity or location from which the sample increment was obtained.
- iv. Type of inspection or test activity and procedure used (reference to standard method when appropriate).
- v. Recorded observation or test data, with all necessary calculations.
- vi. Results of the inspection or test activity and comparison with specification requirements.
- vii. Photographs deemed appropriate by Owner's Representative.
- viii. Personnel involved in the inspection or test activity.
- ix. Signature of the Owner's Representative.

Items above shall be formulated into checklists so that details are not overlooked.

5. Problem/Corrective Action

5.1 Problem/Corrective Action Reports

A problem is defined as material or workmanship that does not meet the project specifications or drawings. Problem/Corrective Action Reports will be cross-referenced to specific inspection entries in the Inspection and Test Log Book where the problem was identified. Problem/Corrective Action Reports will include the following information:

- i. Unique identifying sheet number for cross-referencing and document control.
- ii. Detailed description of the problem.
- iii. Location of the problem.
- iv. Probable cause.
- v. How and when the problem was located (reference to Inspection and Test Log Book).
- vi. Estimation of how long problem has existed.
- vii. Suggested corrective action.
- viii. Documentation of correction (reference to Inspection and Test Log Book).
- ix. Final results.
- x. Photographs were deemed appropriate to Owner's Representative.
- xi. Suggested methods to prevent similar problems.
- xii. Signature of the appropriate CQA support personnel, signature by the Owner's Representative, and signature by Contractor Representative.

In some cases, not all the above information will be available or obtainable.

6. Project Meetings

Project meetings, as detailed herein, will be held during the construction period to ensure that all tasks are accomplished according to schedule and that they are completed in accordance with the project specifications and drawings. As discussed below, these progress meetings may be attended by the Project Manager, Project Coordinator, Owner's Representative, Owner, Contractor and other agencies or subcontractors or project support personnel, as appropriate. The nature and content of the project meetings, as well as anticipated attendees, are detailed below.

6.1 Preconstruction Meeting

Purpose: To review the general project scope, resolve any uncertainties in the project specifications and construction drawings, and to review levels of responsibility, reporting requirements, and health and safety requirements.

Attendance: Project Manager (optional), Project Coordinator, Owner's Representative, Owner (optional), and Contractor.

Topics:

- Introduce each organization and Site personnel.
- Present CQA/QCP, Contractors Site-specific HASP, including applicable Covid-19 site-specific protocols and safety documentation, and other relevant documents.

- Review the activities to be conducted during the construction.
- Review roles of each organization relative to the construction contract design criteria, drawings and specifications, and requirements within the CQA/QCP.
- Determine any modifications to the CQA/QCP that may be necessary to ensure that the construction is performed to meet or exceed the specified design criteria.
- Review lines of authority and communication.
- Discuss the established procedures or protocol for observations and tests including sampling and testing strategies, and waste disposal characterization.
- Discuss the established procedures or protocols for handling construction deficiencies, repairs, and retesting.
- Review methods for documenting and reporting inspection data.
- Review methods for distributing and storing documents and reports.
- Review work area delineation, security and safety protocol including a review of emergency actions.
- Discuss the location for storing construction equipment and materials, and the protection of these items during inclement weather.
- Review of the project schedule.
- Establish a schedule of meetings and briefings during RA activities.
- Identify procedures to resolve disputes or misunderstandings during construction.
- Discuss the protection of uncompleted construction work during off hours and during inclement weather.
- Conduct a Site tour to review construction areas, and equipment and stockpile storage locations.

6.2 Daily Progress Meetings

Purpose: To daily review work schedule progress. This meeting is intended to be an informal meeting held at the start or at the end of each work day.

Attendance: Owner's Representative, Contractor Representative(s), and others, as appropriate.

Topics:

- Review previous day's activities and progress.
- Review work location and activities for upcoming day.
- Review health and safety deficiencies from the previous work day and review health and safety requirements and potential problems for the next day's activities.
- Review Contractor's personnel and equipment assignments for the upcoming day.
- Discuss any potential construction problems.

6.3 Weekly Progress Meetings

Purpose: To provide an update of work schedule progress on a weekly basis, and to identify schedule slippages and efforts required to get back onto schedule, if required.

Attendance: Owner's Representative, Project Manager or Project Coordinator (optional), Owner (optional), Contractor Representative(s), Safety Officer (optional). Weekly meetings will not be necessary for those weeks in which a monthly progress meeting is held.

Topics:

- Review work activities for the previous week.
- Health and safety report for previous and for the coming week's activities.

- Comparison of actual progress to scheduled work activities, noting of schedule slippages and actions to be implemented to rectify schedule slippages.
- Review work activities for the next week.
- Review the Contractor's personnel and equipment assignments for the upcoming week.
- Review potential construction problems and proposed solutions.

6.4 Monthly Progress Meetings

Purpose: May be conducted informally by conference call, or may be combined with weekly meeting, if appropriate.

Attendance: Owner's Representative, Project Manager or Project Coordinator, Owner, Contractor Representative(s), Safety Officer (optional).

Topics:

- Review of the work activities for the previous month.
- Comparison of actual progress to scheduled work activities, noting of schedule slippages/variances and actions implemented to rectify schedule slippages/delays.
- Summarize work activities scheduled for the next month.
- Review potential construction problems/conflicts for the next month's construction activities and proposed solutions to the potential problems/conflicts.

6.5 Problem or Work Deficiency Meetings (As Needed)

Purpose: To address any problems or deficiencies which have or are likely to occur.

Attendance: Owner's Representative, Contractor Representative(s), and others, as appropriate.

Topics:

- Define and discuss problem or deficiency.
- Review alternative solutions.
- Develop and implement a plan to resolve the problem or deficiency.

For all meetings held on Site during the remedial construction, except for the daily progress meetings, minutes will be taken by the Owner's Representative. Copies of the minutes will be forwarded to the Project Manager, the Owner, and all organizations present at the meetings and will be maintained as part of the field documentation file.

7. Project Documentation

7.1 Final Inspections and Final Engineering Report

The pre-final inspection shall consist of a walk-through of the Site to determine completeness of construction and its consistency with the final RD and applicable federal and state laws, rules, and regulations. If any items have not been completed, the Owner's Representative will develop a punch list which details the outstanding items still requiring completion or correction, including an implementation schedule, before acceptance of work.

A final inspection shall be conducted when all the items on the punch list have been completed. All items indicated as requiring correction on the punch list will be re-inspected. A final punch list will be developed for any outstanding items still requiring correction.

Inspection and corrective action reports, if any, will be submitted within 14 days of completion of field inspection/corrective action implementation.

The Owner's Representative will submit a draft Final Engineering Report (FER). The draft FER will include, at a minimum, the following sections and information:

1. Introduction

- A brief description of the location, size, environmental setting, and operational history of the Site.
- A description of the major findings and results of Site investigation activities.
- A description of prior removal and remedial activities at the Site.

2. Background

- A summary of the requirements specified in the RD including the cleanup objectives, institutional; controls (ICs), monitoring requirements, operation and maintenance (O&M) requirements, and other parameters applicable to the design, construction, operation, and performance of the RA.
- Additional information regarding the basis for determining the cleanup objectives, including planned future land use.
- A summary of the RD, including any significant regulatory or technical considerations or events occurring during the preparation of the RD.

3. Construction Activities

- A step-by-step summary description of the activities undertaken to construct and implement the RA (e.g., mobilization and Site preparatory work; earthwork, quantity of material excavated, cleanup levels achieved, materials and/or equipment used, post-excavation activities, including source(s) of any clean fill, the types of fill material used, the final grading and contouring of each area excavated, all other Site restoration activities, all remedial construction equipment decontamination, and removal; associated Site work, such as fencing and water collection and control; and sampling activities).
- A photographic log that documents the progress of remedial construction including, at a minimum, the important features of the Site prior to the commencement of the work, remedial construction activities for the various tasks, and the appearance of the Site after the remedial construction has been completed.

4. Chronology of Events

- A tabular summary that lists the major events for the RA and associated dates of those events.
- A summary of significant milestones and dates, such as, RD submittal and approval; mobilization and construction for the remedy; required inspections; equipment decontamination, dismantlement, and removal; demobilization.

5. Performance Standards and Construction Quality Control

- A description of the Performance Standards.
- An assessment of performance data quality including a discussion of CQA/QC procedures followed, and any substantial problems or significant deviations that occurred during construction.
- A summary of the amount of impacted sediment and soil excavated, its temporary storage, characterization sampling, and load-out, on-Site or off-Site treatment prior to disposal, and the final disposal volumes and locations.
- Documentation that all Performance Standards have been met and an assurance that the RA construction was completed in compliance with the requirements of the RD.

6. Final Inspection and Certifications

- The results of the various RA inspections, punch-list items identified and completion/correction status for these items. The final resolution of all items should be documented.
- A briefly description of the health and safety requirements while implementing the RA and any substantial problems or deviations.

- A summary of the ICs if implemented (e.g., the type of IC, who will maintain the control, who will enforce the control).
7. As-Built Drawings
 - The as-built engineering drawings which depict the RA as implemented. Modifications if any to the approved plans and specifications of the RD will be reported and shown on the as-built drawings. The reasons for all such modifications will be described in detail.
 - The as-built drawings shall be signed and stamped by a professional engineer licensed to practice in the State of Michigan, and shall include a certification that the construction of the soil RA has been completed in conformance with the final RD.
 8. O&M
 - A description of the general activities for post-construction O&M, monitoring, and Site maintenance.
 - Identification of potential problems or concerns with such activities.
 9. Contact Information
 - Contact information (names, addresses, phone numbers, and contract/reference data) for the major design and remediation Contractors, as applicable.
 10. Appendices
 - Supplemental information in appendices to the RA Report.

7.2 Storage of Records

During construction, the Owner's Representative will maintain a copy of the following CQA/QC related documents in the Site office:

- RD and drawings.
- Project Specifications.
- CQA and RA CQC inspection and test results.
- Contractor submittals.
- Contractor's Daily Site Log Book including photo documentation.
- CQA Inspection Log Book.
- Problem/Corrective Action Reports.

Once the construction is complete, all CQC/QA documents (originals) will be retained by the Owner for record retention.

Table 3.1
Summary of Construction Quality Assurance Inspections
RACER Trust
Eckles Road Site, Livonia, Michigan

Work Task Component to be Inspected	Items to be Checked During Inspection	Type of Inspection	Frequency of Inspection	Submittals to CQA Officer	Responsibility of Inspection
1. Synthetic Materials (Geotextile (Section 31 05 19), Drainage geocomposite (31 05 19.26) and Geomembranes (31 05 20))					
a) Delivery, storage, and maintenance	• does material comply with specifications • are manufacturer's seals and labels in tact • is material stored and handled according to manufacturer's recommendations and ASTM D4873, indoors, in manufacturer's original covers • are defects and/or damage evident following delivery to the site	• check certificates • visual • visual • visual	• prior to delivery to site • upon delivery • continuous • upon delivery	• product data • manufacturer's certificates • manufacturer's instructions • none	• Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative & Contractor
c) Installation	• is the subbase free of ruts and harmful objects • is the material weighted against wind uplift • is proper care taken during trimming to prevent damage to liner • are patches installed according to specifications • has installed material been approved before covering • is the materials covered before rain or snowfall • is the soil being placed in direction of shingling • is the cover soil placed so the material is not damaged or wrinkled • is the cover soil placed so no excess tensile stress is developed in material • has the installed material been covered within the time frame recommended by the manufacturer • are weather conditions acceptable for panel placement	• visual • visual • check manufacturer's instructions • visual • visual • visual • visual • visual • visual • check manufacturer's instructions • visual	• continuous • continuous • continuous • continuous • continuous • continuous • continuous • continuous • continuous • continuous • upon installation	• none • none • manufacturer's instructions • none • none • none • none • none • none • manufacturer's instructions • manufacturer's instructions	• Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative • Owner's Representative
2. Drainage Piping (Section 33 41 00)					
a) Material	• are materials in accordance with specifications	• check supplier's specifications	• prior to delivery	• product data	• Contractor
b) Installation	• has pipe been laid to design depth in accordance with drawings • has pipe been damaged or filled with soil during installation • is bedding placed in accordance with specifications • is warning tape installed and visible • is inlet water level control structure installed in accordance with specifications • has trench been properly backfilled in accordance with specifications • is aggregate cover over pipe placed in accordance with drawings	• visual & check drawings • visual • visual & check specification • visual • visual & check specification • visual & check specification • visual & check drawings	• upon installation • upon installation • upon installation • upon installation • upon installation • upon installation • prior to and immediately after placement	• installer's certificate • none • see spec • none • see spec • none • see spec	• Owner's Representative & Contractor • Contractor • Contractor • Contractor • Owner's Representative & Contractor • Owner's Representative & Contractor • Owner's Representative & Contractor

Table 3.2
Summary of Quality Assurance Testing
RACER Trust
Eckles Road Site, Livonia, Michigan

Work Task Component to be Tested	Type of Testing	Method of Testing	Frequency of Testing	Criteria	Responsibility of Testing
1. Geotextile (Section 31 05 19)					
a) Material	- Unit Weight - Thickness - Grab Tensile Strength - Grab Elongation at Break - Static CBR Puncture - Trapezoid Tear Strength - Apparent Opening Size (AOS) - Permittivity - Permeability - Water Flow Rate - UV Resistance	- ASTM D5261 - ASTM D5199 - ASTM D4632/D4632M - ASTM D4632/D4632M - ASTM D6241 - ASTM D4533/D4533M - ASTM D4751 - ASTM D4491 - ASTM D4491 - ASTM D4491 - ASTM D4533/D4533M - Section 31 05 19, Part 3.04 (overlaps in conformance with manufacturer's instructions)	- per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec	12 oz/yd² 120 mils 300 pounds 50% 800 pounds 115 pounds 100 U.S. Sieve 0.8 sec⁻¹ 0.18 cm/s 60 gpm/ft² 70% retained per 500 hours - per spec	- Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor
b) Installation	In accordance with manufacturer's instructions and Section 31 25 19	Section 31 05 19, Part 3.04 (overlaps in conformance with manufacturer's instructions)	per spec	per spec	Contractor
2. Drainage Geocomposite (Section 31 05 19.26)					
Geocomposite					
a) Material	- Transmissivity - Ply Adhesion	- ASTM D4716 - ASTM D7005	- per spec - per spec	9.0 x 10⁻⁴ m²/sec 1.0 psi	- Contractor - Contractor
Geonet Core					
a) Material	- Thickness - Density - Carbon Black Content - Tensile Strength - Transmissivity	- ASTM D5199 - ASTM D1505 - ASTM D4218 - ASTM D7179 - ASTM D4716	- per spec - per spec - per spec - per spec - per spec	300 mils 0.94 g/cm³ 2.0% 75 pounds 8.0 x 10⁻³ m²/sec	- Contractor - Contractor - Contractor - Contractor - Contractor
Geotextile					
a) Material	- Fabric Weight - Grab Tensile Strength - Grab Elongation at Break - Static CBR Puncture - Trapezoid Tear Strength - Apparent Opening Size (AOS) - Permittivity - Water Flow Rate - UV Resistance	- ASTM 5261 - ASTM D4632/D4632M - ASTM D4632/D4632M - ASTM D6241 - ASTM D4533/D4533M - ASTM D4751 - ASTM D4491 - ASTM D4491 - ASTM D4533/D4533M	- per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec	6 oz/yd² 160 pounds 50% 450 pounds 65 pounds 70 mm (maximum) 1.5 sec⁻¹ 110 gpm/ft² (minimum) 70% retained per 500 hours - per spec	- Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor
b) Installation	- In accordance with manufacturer's instructions and Section 31 05 19.26 - Overlap geotextile fabric and bond by thermal methods, or sewing according to manufacturer's instructions - HDPE geonet core to be butt joined or overlapped (except joints on slopes that are perpendicular to slopes which shall be overlapped at least 2 feet) - Apply nylon/plastic cable ties to net edge at 5 ft intervals	- Use of low ground pressure equipment for spreading overlying stone thickness - Section 31 05 19, Part 3.3 - Section 31 05 19, Part 3.3 - Section 31 05 19, Part 3.3	- per spec - per spec - per spec - per spec	- per spec - per spec - per spec - per spec	- Contractor - Contractor - Contractor - Contractor
3. Geomembranes (31 05 20)					
a) Material	- Thickness - Thickness (lowest of 10 coupon values) - Density - Grab Tensile Strength - Grab Strength at Yield - Grab Elongation at Break - Grab Elongation at Yield - Carbon Black Content - Puncture Resistance - Tear Resistance - Standard Oxidation Induction Time (OIT)	- ASTM D5994 - ASTM D5994 - ASTM D1505/ASTM D792 - ASTM D6693 Type IV - ASTM D6693 Type IV - ASTM D6693 Type IV - ASTM D6693 Type IV - ASTM D5596 - ASTM D4833/D4833M - ASTM D1004 - ASTM D3895	- per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec - per spec	60 mils 54 mils 0.94 g/cm³ 240 pounds per inch 132 pounds per inch 700% 12% 9 in Cat.1 or 2 and 1 in Cat. 3 120 pounds 42 pounds >100	- Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor - Contractor
b) Installation	- In accordance with manufacturer's instructions and Section 31 05 20 - Non-destructive seam testing - Seam Shear Test on Test Seam - Seam Peel Test on Test Seam - Defects and Repairs	- As per manufacturer's instructions - ASTM D5820 or ASTM D5641/D5641M - GRI Test Method GM14 - GRI Test Method GM14 - Section 31 05 20, Part 3.7L	- per spec - one sample per 1,000 lineal feet - one sample per 1,000 lineal feet - continuous	- per spec - per spec - per spec - per spec	- Contractor - Contractor - Contractor - Contractor - Contractor

Appendices

Appendix A

Project Specifications

SECTION 31 05 19

GEOTEXTILES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Installation of geotextile material in accordance with drawings.
- B. Related Requirements:
 - 1. Section 31 05 19.26 – Drainage Geocomposite.
 - 2. Section 31 05 20 – Geomembranes.

1.2 PRICE AND PAYMENT PROCEDURES

- A. Measurement and Payment:
 - 1. Section 01 00 00 - General Requirements: Requirements for measurement and payment.
 - 2. Supplying Geotextile:
 - a. Schedule of Prices Item No. 31 05 19/1.
 - b. Measurement Basis: Per square yard measured on the roll, as provided by the manufacturer. The quantity measure for payment will be rounded to the nearest integer square yard completed in that application.
 - c. Payment Basis: Unit price. The amount paid will be the product of the area on each roll as provided by the manufacturer, multiplied by the corresponding Contract Unit Price per square yard. Includes supply and temporary storage.
 - 3. Placing Geotextile:
 - a. Schedule of Prices Item No. 31 05 19/1.
 - b. Measurement Basis: Per square yard measured in place from horizontal projection of area covered with geotextile, not including anchor trenches, after that work is determined complete by the OWNER. The quantity measure for payment will be as measured and rounded to the nearest integer square yard completed in that application.
 - c. Payment Basis: Unit price. The amount paid will be the product of the area measure for payment multiplied by the corresponding Contract Unit Price per square yard. Includes installation, seaming, connection to penetrations, testing, anchoring, overlaps.

1.3 REFERENCES

- A. Abbreviations and Acronyms:
 - 1. AOS: Apparent Opening Size.
 - 2. CBR: California Bearing Ratio.
 - 3. CD: Cross Direction.
 - 4. MD: Machine Direction.
 - 5. UV: Ultra Violet.
- B. Definitions:

1. Geotextile: Synthetic fabric for use in geotechnical filter, separation, stabilization, or erosion control applications.
2. Minimum Average Roll Value (MARV): Average value for a specified parameter less two standard deviations.

C. Reference Standards:

1. Section 01 00 00 - General Requirements: Requirements for references.
2. ASTM International:
 - a. ASTM D4354 - Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing.
 - b. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 - c. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - d. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 - e. ASTM D4759 - Standard Practice for Determining the Specification Conformance of Geosynthetics.
 - f. ASTM D4873 - Standard Guide for Identification, Storage and Handling of Geosynthetic Rolls and Samples.
 - g. ASTM D5261 - Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.
 - h. ASTM D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
 - i. ASTM D7238 - Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus.
3. Geosynthetic Institute:
 - a. GRI Test Method GT12(a), ASTM Version - Standard Specification for Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials.

1.4 COORDINATION

- A. Coordinate installation of geotextile with surface preparation.

1.5 PRE-INSTALLATION MEETINGS

- A. Section 01 00 00 - General Requirements: Pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this Section.
- C. Purpose of Meeting:
1. Define Site-specific quality control and monitoring procedures.
 2. Discuss pre-installation submittals.
 3. Identify daily schedule.

1.6 SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for submittals.
- B. Product Data: Submit no later than 14 days following Notice to Proceed.

- C. Samples: Submit a representative sample at least 6 foot by roll width of geotextile no later than 14 days following Notice to Proceed.
- D. Manufacturer's Instructions: Submit at least 14 days prior to installation. Include installation, handling, storage, and repair instructions.
- E. Manufacturer's Certificates:
 - 1. Deliver each roll to the Site accompanied by manufacturer's certificate.
 - 2. Identify each roll by unique manufacturing number.
 - 3. Include results of tests specified in PART 2, and manufacturer's records for storage, handling, and shipping of geotextile.
 - 4. Certificates shall be signed by the responsible person in charge of the laboratory and notarized.

1.7 CLOSEOUT SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for closeout submittals.
- B. Project Record Documents: Indicate panel layout, including panel identifiers, date placed, installer's name, location of seams, and location and details of repairs.
- C. Warranties: Completed original warranty forms filled out in OWNER's name and registered with manufacturer.

1.8 QUALIFICATIONS

- A. Installer: Company specializing in the installation of geotextile with minimum five projects, 5 million sq ft installation, and 3 years documented experience.
- B. Manufacturer: Submit no later than 14 days prior to following the Notice to Proceed, a list of at least 10 previous projects totaling 10 million sq ft of installation and 3 years documented experience, including name of project, description of project, area, client's name and address, contacts and telephone numbers; engineer's name, address, contact and telephone number; installer's name, address, contact and telephone number; and date installed.
- C. Geosynthetic Testing Laboratory: Submit Geosynthetic Accreditation Institute-Laboratory Accreditation Program (GAI-LAP) certificate.
- D. Notify ENGINEER three days in advance of delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of geotextile or of the entire geotextile roll at ENGINEER's discretion. Remove rejected material from the Site and replace with new material.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 00 00 - General Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Deliver geotextile bearing manufacturer's seals and labels intact. Clearly label each roll to show geotextile identification, date of manufacture, lot number, analysis of contents, and special instructions.

- C. Store and handle geotextile according to manufacturer's recommendations and ASTM D4873, indoors, in manufacturer's original covers. Protect from moisture, dust, light, and heat.
- D. Notify ENGINEER three days in advance of delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of geotextile or of the entire geotextile roll at ENGINEER's discretion. Remove rejected material from the Site and replace with new material.

1.10 AMBIENT CONDITIONS

- A. Install geotextile in dry conditions and according to manufacturer's instructions.
- B. Suspend installation operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing geotextile to the requirements of this Section.

1.11 WARRANTY

- A. Furnish 5-year manufacturer's warranty against manufacturing defects.
- B. Warranty: Include coverage for:
 - 1. Defective products found to be not in compliance with the requirements of this Section.
 - 2. Replacement of the geotextile with new material including costs associated with geotextile installation.

PART 2 PRODUCTS

2.1 GEOTEXTILE

- A. General:
 - 1. Rot-proof, mildew-proof, and not subject to attack by insects or rodents.
 - 2. Capable of retaining its structure during handling, placement, and long-term service.
- B. Description:

1. Non-woven, needle punched geotextile of 100 percent polypropylene, combining high modulus, permeability, and strength. Any roll in a lot shall meet or exceed the following values:

Test	Unit	Test Method	MARV
Unit Weight	ounce/yd ²	ASTM D5261	12
Thickness	mils	ASTM D5199	120
Grab Tensile Strength	pound	ASTM D4632	300
Grab Elongation at Break	percent	ASTM D4632	50
Static CBR Puncture	pound	ASTM D6241	800
Trapezoid Tear Strength	pound	ASTM D4533	115
AOS	US Sieve	ASTM D4751	100
Permittivity	sec ⁻¹	ASTM D4491	0.8
Permeability	cm/s	ASTM D4491	0.18
Water Flow Rate	gpm/ft ²	ASTM D4491	60
Ultra Violet Resistance	percent retained/ 500 hours	ASTM D4355	70

2.2 ANCHORS

- A. In accordance with geotextile manufacturer's recommendations.

2.3 SOURCE QUALITY CONTROL

- A. Section 01 00 00 - General Requirements: Testing, inspection, and analysis requirements.
- B. Manufacturer Quality Control:
 1. Sample and test geotextile material at a minimum once every 10,000 sq ft for unit weight, tensile strength, elongation, hydraulic burst strength, CBR puncture strength, and trapezoid tear strength to demonstrate that the material conforms to requirements specified in Article 2.1. Test for UV stability and AOS at a minimum once every month.
 2. Perform samples on sacrificial portions of material so that repair of material is not required.
 3. As a minimum, each type of geotextile to be shipped to the Site shall be randomly sampled for testing in accordance with ASTM D4354. Acceptance of geotextile shall be based on ASTM D4759.
 4. If geotextile sample fails to meet the quality control requirements of this Section, sample and test each roll manufactured in the same lot, or at the same time, as the failing roll.

- Continue sampling and testing of rolls until a pattern of acceptable test results is established.
5. At geotextile manufacturer's discretion and expense, additional testing of individual rolls may be performed to more closely identify the non-complying rolls and/or to qualify individual rolls.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Section 01 00 00 - General Requirements: Verification of existing conditions before starting work.
- B. Verify with ENGINEER that surfaces and Site conditions are suitable prior to initiating geotextile work.

3.2 PREPARATION

- A. Prior to geotextile placement, where possible roll the surface with a vibratory smooth drum steel or pneumatic roller to avoid irregularities, loose earth, and abrupt changes in grade. Provide necessary equipment and personnel to maintain an acceptable supporting surface during fabric installation.
- B. Examine geotextile for defects including rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or handling.
- C. Remove defective or damaged geotextile from the Site.
- D. Prepare anchor trenches according to the Drawings.

3.3 INSTALLATION

- A. Notify ENGINEER at least 24 hours in advance of intention to commence placement of geotextile.
- B. Do not permit placement of overlay materials until ENGINEER has inspected and approved installation of geotextile.
- C. Obtain approval of ENGINEER prior to installation of geotextile.
- D. Place geotextile on a prepared base as shown on the Drawings.
- E. Unfold or unroll geotextile according to manufacturer's instructions, directly on prepared base, in conditions which will prevent damage to both geotextile and base grade. Unsuitable conditions include, but are not limited to moderate to high wind conditions.
- F. Overlap dimensions and the method of joining adjacent sheets shall, as a minimum, be in strict conformance with manufacturer's instructions. Secure geotextile to base grade in anchor trenches as shown on the Drawings.

- G. Do not entrap stones in geotextile during placement.
- H. Do not expose geotextiles to sunlight for more than 30 days, or less if recommended by manufacturer.
- I. Position and deploy geotextile to minimize handling. Lay smooth and free of tension, stress, folds, or creases. Protect properly placed geotextile from displacement, contamination by surface runoff, or damage, until and during placement of overlaid materials.
- J. Place geotextile on sloping surfaces in one continuous length.
- K. Do not permit passage of vehicular traffic directly on geotextile at any time.
- L. Place geotextile by unrolling onto graded surface and retain in position as specified.
- M. Remove and replace damaged or deteriorated geotextile as directed by ENGINEER.
- N. Protect installed geotextile material from dust, fine particles, and debris prior to placing overlying materials.

3.4 FIELD QUALITY CONTROL

- A. Section 01 00 00 - General Requirements: Field inspecting and testing.
- B. ENGINEER will inspect geotextile in place for tears, overlaps, and consistency before placing materials thereon. Damaged sections, as judged by ENGINEER, will be marked and their removal from the work area recorded. Repair minor damage and minor defects as specified in manufacturer's procedures when approved by ENGINEER to ENGINEER's satisfaction.
- C. ENGINEER will verify that weather conditions (air temperature, non-excessive wind, and lack of precipitation) are acceptable for panel placement.
- D. Conformance Testing:
 - 1. Samples of geotextiles may be collected by ENGINEER according to ASTM D4354 and sent to laboratory for testing to ensure conformance with the requirements of this Section. Geotextile acceptance will be based on ASTM D4759.
 - 2. This testing will be carried out prior to installation of geotextile.
 - 3. Geotextile material that does not comply with requirements specified in PART 2 will be rejected by ENGINEER. Replace rejected material with suitable material, at no additional cost to OWNER.

END OF SECTION

SECTION 31 05 19.26

DRAINAGE GEOCOMPOSITE

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Drainage geocomposite for construction of impermeable cover system.
- B. Related Requirements:
 - 1. Section 31 05 19 – Geotextiles.
 - 2. Section 31 05 20 – Geomembrane.

1.2 PRICE AND PAYMENT PROCEDURES

- A. Measurement and Payment:
 - 1. Section 01 00 00 - General Requirements: Requirements for measurement and payment.
 - 2. Supplying Drainage Geocomposite:
 - a. Schedule of Prices Item No. 31 05 19.26/1.
 - b. Measurement Basis: Per square yard measured on the roll, as provided by the manufacturer. The quantity measure for payment will be rounded to the nearest integer square yard completed in that application.
 - c. Payment Basis: Unit price. The amount paid will be the product of the area on each roll as provided by the manufacturer, multiplied by the corresponding Contract Unit Price per square yard. Includes supply and temporary storage.
 - 3. Placing Drainage Geocomposite:
 - a. Schedule of Prices Item No. 31 05 19.26/1.
 - b. Measurement Basis: Per square yard measured in place from horizontal projection of area covered with drainage geocomposite, not including perforated pipe trenches, after that work is determined complete by the OWNER. The quantity measure for payment will be as measured and rounded to the nearest integer square yard completed in that application.
 - c. Payment Basis: Unit price. The amount paid will be the product of the area measure for payment multiplied by the corresponding Contract Unit Price per square yard. Includes installation, seaming, connection to penetrations, testing, anchoring, and overlaps.

1.3 REFERENCES

- A. Abbreviations and Acronyms:
 - 1. AOS: Apparent Opening Size.
 - 2. CD: Cross-machine direction.
 - 3. HDPE: High density polyethylene.
 - 4. MD: Machine direction.
- B. Definitions:
 - 1. Geotextile: Synthetic filter fabric for use in geotechnical filter applications.

2. Drainage Geocomposite: Synthetic HDPE geonet material with prefasted geotextile fabric for use as a drainage layer.
3. Wrinkles: Corrugations which will fold over during placement of overlying material.
4. Conform to ASTM D4439 for interpretation of terms used in this Section.

C. Reference Standards:

1. Section 01 00 00 - General Requirements: Requirements for references.
2. ASTM International:
 - a. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
 - b. ASTM D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle Furnace Technique.
 - c. ASTM D4355/D4355M - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc-Type Apparatus
 - d. ASTM D4439 - Standard Terminology for Geosynthetics.
 - e. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
 - f. ASTM D4533/D4533M - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - g. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 - h. ASTM D4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
 - i. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
 - j. ASTM D5199 - Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
 - k. ASTM D5261 - Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.
 - l. ASTM D6241 - Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
 - m. ASTM D7005 - Standard Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites.
3. Geosynthetic Research Institute:
 - a. GRI-GC8 - Standard Guide for Determination of the Allowable Flow Rate of a Drainage Geocomposite.

1.4 COORDINATION

- A. Coordinate the installation of drainage geocomposite with liner installation.

1.5 PRE-INSTALLATION MEETING

- A. Section 01 00 00 - General Requirements: Pre-installation meeting.
- B. Convene 1 week prior to commencing work of this Section.
- C. Purpose of Meeting:
1. Define the responsibilities of each party.
 2. Establish lines of authority and lines of communication.
 3. Establish Site-specific quality control and monitoring procedures.
 4. Define installation procedures.

5. Define the method of acceptance of the completed drainage geocomposite.
6. Define installation schedule.
7. Discuss submittals.
8. Review methods for measuring production.
9. Review methods for protecting installed work.

1.6 SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for submittals.
- B. Product Data: Submit no later than 14 days prior to ordering. Include installation, handling, storage, and repair instructions.
- C. Layout Drawings: Provide drawings of the proposed drainage geocomposite placement pattern and field seams no later than 14 days prior to shipping. Indicate panel configuration and location of seams.
- D. Samples: A representative Sample of at least 2 feet by roll width no later than 14 days prior to ordering.
- E. Manufacturer's Certificates:
 1. Certificates pertaining to the rolls of material delivered to the Site shall accompany the rolls. Each roll shall be identified by a unique manufacturing number and shall reference the specific rolls of geotextile fabric and gridded HDPE geonet incorporated into the drainage net construction.
 2. Include test data for all parameters specified in PART 2.
 3. The quality control certificates shall be signed by a responsible party employed by drainage geocomposite manufacturer and shall be notarized.
 4. Certificates pertaining to raw materials and manufactured drainage geocomposite rolls shall be provided from drainage geocomposite manufacturer. ENGINEER will review the test results for completeness and for compliance with the required minimum properties for both the raw materials and manufactured drainage geocomposite rolls. Materials and rolls which are in non-compliance with the minimum required properties will be rejected.
- F. Daily Field Installation Reports:
 1. Provide daily reports of the following:
 - a. Total amount and location of drainage geocomposite placed.
 - b. Identifiers of rolls and fabricated blankets.
 - c. Quality control tests of materials used during the day.
 - d. Total amount and location of seams completed.
 - e. Seaming procedures used.
 - f. Changes in layout drawings.
 - g. Location and type of repairs.
 - h. Observations of seams around appurtenances and connection to appurtenances.
- G. Manufacturer's Instructions: Submit manufacturer's installation instructions no later than 14 days prior to installation.
- H. Installer Qualifications: Submit a copy of manufacturer's approval letter or license no later than 14 days prior to commencing installation.
- I. Manufacturer's Qualifications: Submit, no later than 14 days prior to ordering, a list of previous projects totaling 3 million sq ft of installation, and five projects including name of project,

description of project, area, client's name and address, contacts, and telephone numbers; engineer's name, address, contact, and telephone number; installer's name, address, contact, and telephone number; and date installed.

- J. Transmissivity Testing Reports: Submit no later than 10 days prior to ordering.

1.7 CLOSEOUT SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for closeout submittals.
- B. Project Record Documents: Indicate panel layout, including panel identifiers, date placed, installer's name, location of seams, and location and details of repairs.
- C. Warranties: Completed original warranty forms filled out in OWNER's name and registered with manufacturer.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum ten projects, 10 million sq ft, manufacturing, and 3 years documented experience.
- B. Installer: Trained and qualified to install the type of drainage geocomposite to be used for the project and an approved and/or licensed installer of drainage geocomposite manufacturer with minimum five projects, 5 million sq ft installation, and 3 years documented experience. Submit a copy of the approval letter or license to ENGINEER.
- C. Seamers: Personnel performing seaming operations shall be qualified by experience with a minimum of 3 years experience.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 00 00 - General Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Package and label drainage geocomposite rolls or blankets prior to shipment to the Site. The label shall indicate drainage geocomposite manufacturer, type of drainage geocomposite, and roll or blanket number.
- C. When transported to the Site, handle drainage geocomposite rolls or blankets according to manufacturer's instructions so that no damage is caused.
- D. Protect drainage geocomposite from direct sunlight and heat to prevent degradation of drainage geocomposite material and adhesion of individual whorls of a roll or layers of blanket.
- E. Take adequate measures to keep drainage geocomposite materials away from possible deteriorating sources.
- F. Use handling equipment approved by manufacturer when moving rolled or folded drainage geocomposite from one place to another.

- G. Notify ENGINEER 3 days in advance of drainage geocomposite delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage will be grounds for rejection of a portion or of an entire roll at the discretion of ENGINEER. Remove roll from the Site and replace with new material. Repair minor damage and other defects as directed by ENGINEER.

1.10 AMBIENT CONDITIONS

- A. Install drainage geocomposite according to manufacturer's installation instructions.
- B. Suspend installation operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing drainage geocomposite to the requirements of this Section.
- C. Weather Conditions for Seaming: Comply with manufacturer's installation instructions.

1.11 WARRANTY

- A. Furnish 20-year manufacturer's warranty against manufacturing defects.
- B. Warranty: Include coverage for:
1. Defective products found to be not in compliance with the requirements of this Section.
 2. Replacement of the drainage geocomposite with new material including costs associated with drainage geocomposite installation.

PART 2 PRODUCTS

2.1 GEOCOMPOSITE

- A. Double-sided, 200 mil thick geonet with bonded 6 oz/yd² geotextile on both sides.
- B. Incorporate a prefabricated gridded HDPE geonet made of overlapping polyethylene strands which transmits fluids in the plane of the net.
- C. Incorporate a nonwoven needle-punched geotextile fabric prefastened to the top surface of HDPE geonet and a nonwoven needle-punched geotextile fabric prefastened to the bottom surface of HDPE geonet.
- D. Geocomposite shall comply with the following specifications:

Property	Unit	Test Method	Minimum Acceptable Value
Transmissivity ⁽¹⁾ • at gradient 2% • at gradient 4%	m ² /s	ASTM D4716	0.0017 0.0013
Ply Adhesion	psi	ASTM D7005	0.5

⁽¹⁾ Normal load of 1,000 psf, boundary condition:
plate/sand/geocomposite/geomembrane/plate, water at 70 degrees F for 100 hours.

E. Geonet core shall comply with the following specifications:

Property	Unit	Test Method	Minimum Acceptable Value
Thickness	mil	ASTM D5199	200
Density	g/cm ³	ASTM D1505	0.94
Carbon Black Content	percent	ASTM D4218	2.0
Creep Reduction Factor	100 hr under 2,000 psf at 70 degrees F	GRI GC8	1.05

F. Geotextile fabric shall conform to acceptable values listed as follows:

Property	Unit	Test Method	Acceptable Value
Fabric Weight	ounce per sq yd	ASTM D5261	6 (minimum)
Grab Strength (MD/CD)	pound	ASTM D4632	160 (minimum)
Grab Elongation (MD/CD)	percent	ASTM D4632	50 (maximum)
CBR Puncture Strength	pound	ASTM D6241	435
Trapezoidal Tear Strength	pound	ASTM D4533/D4533M	65
AOS	Sieve Size mm	ASTM D4751	70 (maximum) 0.212 (maximum)
Permittivity	s ⁻¹	ASTM D4491	1.5 (minimum)
Water Flow Rate	gpm/ft ²	ASTM D4491	110 (minimum)
UV Resistance	percent retained after 500 hrs	ASTM D4355/D4355M	70 (minimum)

PART 3 EXECUTION

3.1 EXAMINATION

- A. Section 01 00 00 - General Requirements: Verification of existing conditions before starting work.
- B. Obtain ENGINEER's approval prior to installing drainage geocomposite and prior to placing subsequent materials on drainage geocomposite.

3.2 PREPARATION

- A. Prior to placement of drainage geocomposite, ensure underlying surfaces are smooth and free of wrinkles. The surface shall provide a firm, unyielding foundation for drainage geocomposite with no sudden, sharp, or abrupt changes or break in grade.
- B. Obtain written approval of surface on which drainage geocomposite is to be installed from manufacturer's field representative (generally designated as the installer) prior to placing drainage geocomposite and prior to placing overlying materials.

3.3 INSTALLATION

- A. Install according to manufacturer's instructions.

- B. Place individual sheets and/or strips of drainage geocomposite side by side without gaps.
- C. Lay drainage geocomposite smooth and free of tension, folds, or wrinkles.
- D. Protect properly placed drainage geocomposite from displacement or damage until and during placement of overlaid materials.
- E. In the presence of wind, secure drainage geocomposite with sandbags until overlying cover materials are installed.
- F. Ensure that the underlying materials are not damaged during placement of drainage geocomposite.
- G. Ensure that stones, mud, and soil are not entrapped in the drainage geocomposite during and following placement and/or seaming operations.
- H. Operation of equipment over geocomposite will be in conformance with the following guidelines:

Average Equipment Ground Pressure (psi)	Min. Lift Thickness Below Tracks (in)
4	4
5	12
6	24

- I. Anchor drainage geocomposite and roll down the slope in such a manner as to continually keep the material in tension. Utilization of the same anchor trench as the flexible membrane liner is preferable.
- J. Overlap geotextile fabric prefastened to the drainage geocomposite to adjoining section of drainage geocomposite according to manufacturer's instructions; bond by thermal methods, or by sewing according to manufacturer's instructions.
- K. If sewing is performed, use thread polymeric material with chemical resistance similar to the geotextile.
- L. HDPE drainage geonet may be butt joined or lapped, except for joints on slopes that are perpendicular to slope direction, which shall be overlapped at least 2 feet.
- M. Apply nylon/plastic cable ties to the net edge at 5-foot intervals along the edge.
- N. Make end splices as follows: On slopes, overlap the upslope sheet 2 feet over the downslope sheet and apply two rows of cable ties parallel to matching edge. Space ties at 2 feet and stagger spacing in the two rows.
- O. Stagger horizontal seams on side slopes between rolls.
- P. Place protective soil or stone cover on the geocomposite in a manner that prevents damage to the geocomposite. Placement of the protective cover shall proceed immediately following the placement and inspection/acceptance of the geocomposite.

3.4 REPAIR

- A. Geotextile:

1. Clean and dry surfaces at the time of repair.
2. Repair holes or tears in geotextiles by patching with the same geotextile.
3. Patches: Minimum of 12 inches larger in all directions than the area to be repaired, and spot bonded thermally.

B. Drainage Geocomposite:

1. Clean and dry surfaces at the time of repair.
2. Repair holes or tears in the drainage net by patching with the same drainage net.
3. Patches: Minimum of 12 inches larger in all directions than the area to be repaired. Tie the patch in place using a minimum of four nylon cable ties.

3.5 INSTALLATION OF MATERIALS IN CONTACT WITH DRAINAGE GEOCOMPOSITE

- A. Place soil cover materials in a manner so as not to damage drainage geocomposite, and according to drainage geocomposite manufacturer's instructions.
- B. Minimize slippage of drainage geocomposite and assure that no tensile stress is induced in the materials.

3.6 FIELD QUALITY CONTROL

- A. Section 01 00 00 - General Requirements: Field inspecting and testing.
- B. Inspect each panel in place for damage, tears, overlaps, and consistency before placing material thereon. Mark damaged panels or portions of damaged panels which have been rejected, as judged by ENGINEER, and record their removal from the work area. Repair or replace damaged or improperly placed sections as judged by ENGINEER.

3.7 MANUFACTURER'S FIELD SERVICES

- A. Manufacturer shall provide a qualified representative to observe installation of drainage geocomposite.
- B. Manufacturer's representative shall have extensive knowledge of drainage geocomposite liner product, specifically as it pertains to proper construction techniques for waste management applications.
- C. Manufacturer's representative shall be on the Site for a minimum of first week of installation and shall remain on the Site until, in its opinion, CONTRACTOR and/or installer can adequately complete the installation in strict accordance with manufacturer's guidelines, specifications, and the installation procedure specified in this Section.

3.8 PROTECTION

- A. Protect finished work from damage.
- B. Do not permit traffic or construction equipment directly on drainage geocomposite.

END OF SECTION

SECTION 31 05 20

GEOMEMBRANE

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. High density polyethylene geomembrane (liner).
- B. Related Requirements:
 - 1. Section 31 05 19 – Geotextile.
 - 2. Section 31 05 19.26 – Drainage Geocomposite.

1.2 PRICE AND PAYMENT PROCEDURES

- A. Measurement and Payment:
 - 1. Section 01 00 00 - General Requirements: Requirements for measurement and payment.
 - 2. Supplying Geomembrane:
 - a. Schedule of Prices Item No. 31 05 20/1.
 - b. Measurement Basis: Per square yard measured on the roll, as provided by the manufacturer. The quantity measure for payment will be rounded to the nearest integer square yard completed in that application.
 - c. Payment Basis: Unit price. The amount paid will be the product of the area on each roll as provided by the manufacturer, multiplied by the corresponding Contract Unit Price per square yard. Includes supply and temporary storage.
 - 3. Placing Geomembrane:
 - a. Schedule of Prices Item No. 31 05 20/2.
 - b. Measurement Basis: Per square yard measured in place from horizontal projection of area covered with geomembrane, not including anchor trenches, after that work is determined complete by the OWNER. The quantity measure for payment will be as measured and rounded to the nearest integer square yard completed in that application.
 - c. Payment Basis: Unit price. The amount paid will be the product of the area measure for payment multiplied by the corresponding Contract Unit Price per square yard. Includes installation, seaming, connection to penetrations, testing, anchoring, and overlaps.

1.3 REFERENCES

- A. Abbreviations and Acronyms:
 - 1. HDPE: High density polyethylene.
 - 2. IAGA: International Association of Geosynthetic Installers.
- B. Definitions:
 - 1. Conform to ASTM D4439 for interpretation of terms used in this Section.
 - 2. Minimum Average Value: Average of test values calculated in accordance with specified standard at minimum frequency specified in GRI Test Method GM13.

3. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined according to ASTM D698.
4. Wrinkles: Corrugations in geomembrane that will fold over during placement of materials overlying geomembrane.

C. Reference Standards:

1. Section 01 00 00 - General Requirements: Requirements for references.
2. ASTM International:
 - a. ASTM D698 – Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft lbf/ft³ (600 kN m/m³)).
 - b. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 - c. ASTM D1004 – Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.
 - d. ASTM D1505 – Standard Test Method for Density of Plastics by the Density Gradient Technique.
 - e. ASTM D1603 – Standard Test Method for Carbon Black Content in Olefin Plastics.
 - f. ASTM D3895 – Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry.
 - g. ASTM D4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle Furnace Technique.
 - h. ASTM D4437/D4437M – Standard Practice For Non Destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
 - i. ASTM D4439 – Standard Terminology for Geosynthetics.
 - j. ASTM D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - k. ASTM D4833/D4833M – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
 - l. ASTM D5199 – Standard Test Method for Measuring Nominal Thickness of Geosynthetics.
 - m. ASTM D5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
 - n. ASTM D5397 – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test.
 - o. ASTM D5596 – Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
 - p. ASTM D5641/D5641M – Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
 - q. ASTM D5820 – Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
 - r. ASTM D5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.
 - s. ASTM D5994 – Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
 - t. ASTM D6370 – Standard Test Method for Rubber Compositional Analysis by Thermogravimetry (TGA).
 - u. ASTM D6392 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
 - v. ASTM D6497 – Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures.
 - w. ASTM D6693 – Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

- x. ASTM D7466 – Test Method for Measuring the Asperity Height of Textured Geomembranes.
- 3. Geosynthetic Research Institute:
 - a. GRI Test Method GM6 – Pressurized Air Test for Dual Seamed Geomembranes.
 - b. GRI Test Method GM9 – Cold Weather Seaming of Geomembranes.
 - c. GRI Test Method GM13 – Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.
 - d. GRI GM14 – Standard Guide for Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attribute.
 - e. GRI Test Method GM19 – Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.
 - f. GRI Test Method GM29 – Standard Practice for Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and Nondestructive Testing.

1.4 PRE-INSTALLATION MEETINGS

- A. Section 01 00 00 - General Requirements: Pre-installation meeting.
- B. Convene a minimum 1 week prior to commencing installation of geomembranes.
- C. Purpose of Meeting:
 - 1. Define responsibilities of each party.
 - 2. Establish lines of authority and lines of communication.
 - 3. Establish Site-specific quality assurance/quality control and monitoring procedures.
 - 4. Define installation procedures.
 - 5. Define method of acceptance of completed geomembrane.
 - 6. Define installation schedule.
 - 7. Discuss submittals.
 - 8. Review personal protective equipment and applicable regulations.
 - 9. Review safety plan and procedures.
 - 10. Review panel layout and numbering system for panels, seams, and test samples.
 - 11. Review methods for protecting installed work.
 - 12. Visit site for review of surface preparation, physical location of site, and site access.
 - 13. Review critical design details.

1.5 SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for submittals.
- B. Shop Drawings: Indicate installation layout, dimensions, and details including field seams, anchor trenches, and protrusion details.
- C. Product Data: Submit no later than 30 days prior to ordering
- D. Manufacturer's Instructions: Submit no later than 14 days prior to installation.
- E. Installer's Quality Assurance Plan or Manual: Submit no later than 30 days prior to installation.
- F. Source Quality Control Submittals: Indicate results of testing no later than 30 days prior to ordering.

- G. Certification from the QC inspector and installer of the acceptability of the surface on which the geomembrane is to be placed, immediately prior to geomembrane placement.
- H. QC inspector certified test results on all field seams. Installer and certified QC laboratory test results on all destructively tested field seams. QC inspector certified test results on all repaired seams. Certified QC test results.
- I. Daily Field Installation Report: submit no later than 1 day following date covered by report. Include:
 - 1. Subgrade surface acceptance form signed by manufacturer's representative and ENGINEER.
 - 2. Total quantity, type, and location of geomembrane placed.
 - 3. Identifiers of rolls with manufacturer's number.
 - 4. Quality control tests of materials used during the day.
 - 5. Total quantity and location of seams completed, identification of seamer, and welding equipment used.
 - 6. Observations of test seams, including seaming unit number and identification of names of seamers, weather conditions, speed, temperature setting, and results.
 - 7. Location and results of non-destructive testing.
 - 8. Location and results of destructive testing.
 - 9. Reasons for and observations of repairs and retesting, including locations, type of repair, name of repairer, and seaming equipment or product used.
 - 10. Observations of anchor trench excavation, backfilling, and compaction.
 - 11. Observations of field seaming operations, including weather conditions, cleaning, overlaps, rate of seaming, names of seamers, and units used.
 - 12. Observations of placement and seams around appurtenances, and connection to appurtenances.
- J. Installer Qualification Statements:
 - 1. Manufacturer's approval of installer no later than 14 days prior to installation.
 - 2. IAGI Certified Contractor Status.
 - 3. IAGI Certificates and Certified Welding Technician Certificates for each seamer.

1.6 CLOSEOUT SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for closeout submittals.
- B. Project Record Documents: Indicate panel layout, including panel identifiers, date placed, installer's name, location of seams, and location and details of repair.
- C. Warranties: Completed original warranty forms filled out in OWNER's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

- A. Provide installer's quality assurance plan or manual to ensure that geomembrane will be installed in accordance with this Section and the noted references.
- B. Certifications: Submit certificates based on GRI required properties and testing frequencies.
 - 1. Certificates pertaining to rolls or panels of geomembrane delivered to the Site shall accompany rolls or panels. Each roll or panel shall be identified by a unique

manufacturing number. Quality control certificates shall be signed by a responsible party employed by manufacturer.

2. Certificates pertaining to raw materials and manufactured rolls or panels shall be provided by geomembrane manufacturer. ENGINEER will review test results for completeness and for compliance with minimum properties specified for both raw materials and manufactured rolls or panels. Materials and rolls or panels which are in non-compliance with minimum properties specified will be rejected

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum ten projects, 20 million sq ft, manufacturing, and 3 years documented experience.
- B. Installer: Company specializing in installing products specified in this Section with minimum five projects, 10 million square feet, 3 years documented experience, certified/licensed by manufacturer, and a holder of IAGI Certified Contractor Status.
- C. Seamers: Certification by IAGI and certification as a Certified Welding Technician is required for all personnel performing seaming operations.
- D. Master Seamer: Same certification requirements as seamer, with at least 10 million sq ft of geomembrane of the same generic type as geomembrane used for the Project using the same type of seaming method. The master seamer will provide direct supervision over all seamers and will be present during all seaming operations.
- E. QC Inspector: A person or corporation hired by CONTRACTOR, who is responsible for monitoring and documenting activities related to the QC of the geomembrane from manufacturing through installation. The QC inspector shall have provided QC inspection during installation of the proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet.
- F. QC Laboratory: The QC laboratory shall have provided QC and/or Quality Assurance (QA) testing of the proposed geomembrane and geomembrane seams for at least five completed projects having a total minimum area of 2 million square feet. The QC laboratory shall be accredited via GAI-LAP for the tests the QC laboratory will be required to perform.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 00 00 - General Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. During storage, protect geomembrane from direct sunlight, ultraviolet rays, excessive heat, mud, dirt, dust, debris, and rodents.
- C. Take adequate measures to keep geomembrane away from possible deteriorating sources (i.e., vandalism, theft).
- D. Use handling equipment approved by manufacturer when moving geomembrane from one place to another. Lift rolls by inserting bar, sized to limit deflection detrimental to geomembrane, through roll core. Attach slings or lifting chains at both ends of bar. Use a spreader bar to support and spread slings. Bar and support pipe shall be long enough to prevent damage to edges of geomembrane during hoisting.

- E. Notify ENGINEER 3 days in advance of geomembrane delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of geomembrane or of the entire geomembrane roll at the discretion of ENGINEER. Remove roll from the Site and replace with new material.

1.10 AMBIENT CONDITIONS

- A. Suspend installation operations whenever climatic conditions, as determined by ENGINEER or manufacturer's representative, are unsatisfactory for placing geomembrane to requirements of this Section.
- B. Weather Conditions for Geomembrane Placement:
 - 1. Comply with manufacturer's recommendation.
 - 2. Do not unroll, unfold, or place geomembrane at an ambient temperature below 32 degrees F or above 104 degrees F, unless CONTRACTOR obtains written approval from geomembrane manufacturer and ENGINEER.
 - 3. Install on dry ground.
 - 4. Geomembrane placement shall take into account site drainage, wind direction, Site construction, access to the Site and production schedule of the Works.
 - 5. Geomembrane placement shall not proceed if subgrade conditions have deteriorated due to moisture, or in the presence of high winds, as determined by ENGINEER, which might damage geomembrane.
 - 6. Adequately ballast deployed geomembrane at all times to limit risk of wind damage.
- C. Weather Conditions for Geomembrane Seaming:
 - 1. Comply with manufacturer's recommendations.
 - 2. Make no weld below 34 degree F unless:
 - a. CONTRACTOR strictly follows guidelines for field seaming of geomembrane in cold weather, as identified in GRI Test Method GM9.
 - b. CONTRACTOR obtains written approval from geomembrane manufacturer to weld at temperature below 32 degrees F to GRI Test Method GM9.
 - 3. Between 34 and 50 degrees F, seaming is possible if geomembrane is preheated by either sun or hot air device, and if there is not excessive cooling resulting from wind.
 - 4. Make no weld below 5 degrees F.
 - 5. In all cases, geomembrane must be dry while being welded.

1.11 WARRANTY

- A. Furnish 20-year manufacturer's warranty against manufacturing defects.
- B. Warranty: Include coverage for:
 - 1. Defective products found to be not in compliance with the requirements of this Section.
 - 2. Replacement of the geomembrane with new material including costs associated with geomembrane installation.

PART 2 PRODUCTS

2.1 HDPE GEOMEMBRANE

- A. A smooth geomembrane designed and manufactured specifically for the purpose of fluid containment.
- B. Free of holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
- C. Shall have good appearance qualities, free of features that may affect the specified properties.
- D. Conforming to the following specifications:

<i>Property</i>	<i>Unit</i>	<i>Test Method</i>	<i>Minimum Average Value⁽¹⁾</i>
Thickness	mil	ASTM D5994	60
• Lowest of 10 coupon values			54
Density	g/cm ³	ASTM D1505/ASTM D792	greater than or equal to 0.940
Tensile Strength at Break	pound/inch	ASTM D6693 Type IV ⁽²⁾	240
Strength at Yield	pound/inch	ASTM D6693 Type IV ⁽²⁾	132
Elongation at Break	percent	ASTM D6693 Type IV ⁽²⁾	700
Elongation at Yield	percent	ASTM D6693 Type IV ⁽²⁾	12
Carbon Black Content	percent	ASTM D1603 and ASTM D4218 ⁽³⁾	2.0 to 3.0 (range)
Carbon Black Dispersion		ASTM D5596	9 in Cat. 1 or 2 and 1 in Cat. 3
Puncture Resistance	pound	ASTM D4833/D4833M	120
Tear Resistance	pound	ASTM D1004	42
Oxidation Induction Time (OIT) ⁽⁴⁾			
• Standard	minute	ASTM D3895	>100

Notes:

- (1) Except as indicated.
- (2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five test specimens each direction; break elongation is calculated using a gage length of 2.0 inches at 2.0 inches/minute.
- (3) Other methods such as ASTM D1603 (tube furnace) or ASTM D6370 (TGA) are acceptable if an appropriate correlation to ASTM D4218 (muffle furnace) can be established.
- (4) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

2.2 SOURCE QUALITY CONTROL

- A. Section 01 00 00 - General Requirements: Testing, inspection, and analysis requirements.
- B. Manufacturer shall perform test for parameters specified in PART 2, at a minimum frequency specified in GRI Test Method GM13.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Section 01 00 00 - General Requirements: Verification of existing conditions before starting work.
- B. Obtain ENGINEER's and manufacturer's approval in writing prior to installing geomembrane and prior to placing subsequent materials on geomembrane.
- C. Coordinate activities so that ENGINEER can observe testing. ENGINEER will observe all testing and collect samples for destructive laboratory testing.

3.2 PREPARATION

- A. Surface Preparation:
 - 1. Do not begin installation of geomembrane until a proper subbase has been prepared and approved by ENGINEER and geomembrane manufacturer's representative. Prepared surface shall be free from abrupt changes in grade, water, loose earth, exposed rocks, rubble, protrusions, vegetation, and other foreign matter which may be damaging to geomembrane. Compact subgrade uniformly to a minimum of 98 percent SMDD and smooth with a drum roller.
 - 2. Do not place geomembrane in an area which has become softened by precipitation and which will not support geomembrane installation equipment without rutting.

3.3 INSTALLATION

- A. Maintain area of installation free of water.
- B. Prepare excessively soft supporting material as directed by ENGINEER.
- C. Do not proceed with panel placement and seaming when ambient temperatures are below 32 degrees F or above 104 degrees F, during precipitation, in presence of excessive moisture (e.g., fog, dew), nor in presence of high winds.
- D. Place geomembranes in accordance with manufacturer's instructions. Minimize wrinkles, avoid scratches and crimps to geomembranes, and avoid damage to supporting material.
- E. Designate each roll or blanket with an individual panel number and correlate with manufacturer's identification number. Mark each designation in each roll as it is deployed.
- F. Protect installed geomembrane from displacement, damage or deterioration before, during and after placement of material layers.

- G. Require workers to wear shoes which will not damage geomembrane.
- H. Minimize pulling of geomembrane panels to reduce permanent tension.
- I. Take the following precautions to minimize the risk of damage by wind during panel placement:
 - 1. Orientate work according to the direction of prevailing winds if possible, unless otherwise specified.
 - 2. Adequately secure the geomembrane panels to prevent uplift by wind, by any means necessary that will not damage geomembrane. Along the edges, ensure loading is continuous, to avoid possible windflow under the panels.
- J. Replace damaged, torn or permanently twisted panels to approval of ENGINEER. Remove rejected damaged panels from the Site.
- K. Keep field seaming to minimum. Locate field seams up and down slopes, with no horizontal field seam less than 5 feet beyond toe or crest of slope.
- L. Keep seam area clean and free of moisture, dust, dirt, debris and foreign material.
- M. Make field seam samples in accordance with requirements specified in PART 2 of this Section on fragment pieces of geomembrane and test to verify that seaming conditions are adequate.
- N. Test field seams as seaming work progresses by non-destructive methods over their full length, in accordance with ASTM D4437/D4437M. Repair seams which do not pass non-destructive test. Reconstruct seam between failed location and any passed test location, until non-destructive testing is successful.
- O. Repair minor tears and pinholes by patching until non-destructive testing is successful. Patches to be round or oval in shape, made of same geomembrane material, and extend minimum of 3 inches beyond edge of defect.

3.4 INSTALLATION AROUND APPURTENANCES

- A. Install geomembrane around appurtenances protruding through geomembrane.
- B. Obtain ENGINEER's written approval for materials to be used to seal gaps between the geomembrane skirt and appurtenances.
- C. Perform installation on rough surfaces carefully to minimize geomembrane damage. Additional loosely placed geomembrane sections may be used by geomembrane installer as protection for geomembrane, if approved by ENGINEER.
- D. Ensure clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane around each appurtenance have a lifespan equal to or exceeding geomembrane.
- E. Geomembrane penetration shall be in accordance with ASTM D6497 or as recommended by geomembrane manufacturer.

3.5 FIELD SEAMING

- A. Keep field seaming to minimum. Locate field seams up and down slopes, with no horizontal field seam less than 5 feet beyond toe or crest of slope.
- B. Overlap the panels a minimum of 4 inches for extrusion welds and a minimum of 4 inches for hot wedge welds.
- C. Panel Preparation: Prior to seaming, clean the seam area and ensure it is free of moisture, dust, dirt, debris of any kind, and foreign material.
- D. Seaming Equipment and Products: Seam geomembrane using extrusion or hot wedge welding equipment and installation methods recommended by manufacturer. For extrusion welding, use an extrudate composition identical to that of the geomembrane material, or weld all panels together using the hot wedge welding system. Include thermometers on the extrusion welding equipment to measure the temperature of the extrudate in the machine extruder and at the nozzle. Use wedge welding equipment capable of continuously monitoring and controlling the wedge temperature.
- E. Orient seams downslope so that direction of seaming will not hinder flow of water over top of geomembrane. Specifically for hot welded seams, overlap geomembrane on downslope side of seam. Extend seaming to outside edge of panels to be placed in anchor trench.
- F. If the supporting soil is yielding, provide a firm substrate by using a homogeneous board, a conveyor belt, or similar hard surface directly under seam overlap to effect proper rolling pressure.
- G. Seaming Wrinkles: Cut fishmouths and corrugations so as to affect a flat overlap. Seam the cut fishmouths or wrinkles as well as possible, then install patch of the same generic geomembrane extending a minimum of 6 inches beyond the cut in all directions.
- H. Do not cross slope seam less than 5 feet from the toe of slope unless slope is less than 10 percent. Cross slope seams may be utilized if cut at an angle of approximately 45 degrees.
- I. Label each seam with date, seamer, equipment seaming temperature and speed, and time seam started and completed.
- J. Seaming Tie-ins: Only proceed with seaming of geomembrane tie-ins once all panels to be seamed are at a uniform temperature (i.e., early in the morning or late in the day) to avoid excessive distortion in the geomembrane due to geomembrane contraction and expansion.

3.6 REPAIR PROCEDURES

- A. Clean and dry surfaces at the time of repair.
- B. Repair pinholes by applying a patch. Repair defective seams by re-seaming, flap welding, or applying a patch, as approved by ENGINEER.
- C. Repair tears, blisters, larger holes, undispersed raw materials, and contamination by foreign matter, or corrugations determined by ENGINEER to be excessive, by patches.
- D. Patches:
 - 1. Abrade surfaces as appropriate.

2. Label each patch date, number, seamer, and equipment.
3. Ensure patches are round or oval in shape.
4. Make of same generic geomembrane.
5. Extend patch a minimum of 4 inches beyond edge of defects.

3.7 FIELD QUALITY CONTROL

- A. Section 01 00 00 - General Requirements: Field inspecting and testing.
- B. Test quality of resin and geomembrane to ensure consistency of raw material and geomembrane quality in accordance with manufacturer's recommendations.
- C. Inspect each panel after placement and prior to seaming for damage. Mark damaged panels or portions of damaged panels which have been rejected, as judged by ENGINEER, and record their removal.
- D. Verify that weather conditions (air temperature, non-excessive wind, and lack of precipitation) are acceptable for panel placement.
- E. Field Seaming Operations: Verify as follows:
 1. Seaming personnel have the specified qualifications.
 2. Overlaps meet specified requirements.
 3. Seaming area is clean and dry, as specified.
 4. A hard substrate such as a board or a piece of conveyor belt is used if the supporting soil is soft or uneven.
 5. Seaming equipment is available and meets specified requirements.
 6. Weather conditions for seaming are acceptable, as specified.
 7. Seaming procedures as specified are followed.
 8. Panels are properly positioned to prevent wrinkling.
 9. Equipment for testing seams is available on site and operational.
 10. Field tensiometer has been correctly calibrated.
- F. Provide test results to ENGINEER, for each shift's production, including documentation of non-destructive testing and repairs at the end of each shift.
- G. Test Seams:
 1. Perform test seams in shear and peel in accordance with GRI Test Method GM29 to verify that seaming conditions are adequate. Conduct test seams at discretion of ENGINEER and at least 2 times each day (at the beginning of each seaming period, at least once every 4 hours thereafter, and at least once every 4 hours thereafter if welding operations are interrupted) for each seaming apparatus and each seamer used that day. Perform test seaming under the same conditions as production seaming. Provide 4 feet test seams for extrusion welds, 10 feet test seams for hot wedge welds. Perform test seams on scrap geomembrane not to be incorporated into the Works.
 2. Cut 1-inch wide coupons from the test seam and assign to peel or shear test alternatively as they are cut across panel. Test coupons in shear and peel using a calibrated field tensiometer. Required minimum strength of geomembrane test seams:
 - a. Seam Shear Test on Test Seam: 90 percent of specified tensile strength at yield of unseamed HDPE geomembrane.
 - b. Seam Peel Test on Test Seam: 60 percent of specified tensile strength at yield of unseamed HDPE geomembrane.
 3. In addition, test coupons must not delaminate. Passing test results must be obtained from 4 of 5 coupons when tested in shear, and 4 of 5 coupons when tested in peel. For

- geomembrane test seams performed using a hot wedge welder, perform peel tests on both inside and outside welds; both welds must pass peel test. If a test seam fails, reject seaming equipment for field seaming until deficiencies are corrected and a successful test seam is produced.
4. A passing test seam will be an indicator of seaming unit adequacy and seamer working under prevailing Site conditions, but not necessarily an indicator of field seam adequacy.
 5. Coordinate completion of test seams such that ENGINEER can observe such seams. ENGINEER will observe all test seams. Retain a sample from each test and label with date, ambient temperature, number of seaming units, seamer, and pass or fail description. One half of sample will be retained by ENGINEER.
- H. Non-destructive Seam Testing:
1. Non-destructively test field double fusion seams with an enclosed channel by air pressure testing according to ASTM D5820 or single welded seams by vacuum testing according to ASTM D5641/D5641M. Test results shall be written on geomembrane near seam. Number or otherwise designate each seam. Record location, date, test unit, name of tester, and outcome of all non-destructive testing.
 2. Passing non-destructive test of field seams, meeting or exceeding requirements according to GRI Test Method GM19, indicates the adequacy of field seams, subject to results of destructive seam testing, as specified in Article 3.7 of this Section.
 3. Coordinate activities such that ENGINEER can observe all testing. ENGINEER will observe all testing. Non-destructive testing performed in absence of ENGINEER shall be repeated. Conduct testing as seaming work progresses. Number and mark all defects found during testing immediately after detection. Repair, retest, and remark all defects found to indicate completion of repair and acceptability. If pressure testing is performed, following testing, repair hole resulting from pressure needle.
- I. Destructive Seam Testing: Collect 2-foot long field seam samples at a frequency of approximately one sample per 1,000 linear feet of field seam at locations directed by ENGINEER, or another predetermined length in accordance with GRI GM14. Field test 5 coupons in peel and five coupons in shear according to GRI Test Method GM19 and ASTM D6392, using a calibrated field tensiometer. Perform peel tests on the inside and outside weld. If at least 4 of each of the 5 coupons do not delaminate and pass tensile strength requirements, based on field testing, then collect additional 2-foot long sample from the same location and provide to ENGINEER for quality assurance laboratory shear and peel testing. Required minimum strength of geomembrane field seams for both field and laboratory tests:
1. Shear Test: 90 percent of specified tensile strength at yield of unseamed HDPE geomembrane.
 2. Peel Test: 60 percent of specified tensile strength at yield of unseamed HDPE geomembrane.
- J. If either field or laboratory tests fail, isolate defective seam and re-test as follows:
1. Collect additional 2-foot long samples from field seam for testing using a field tensiometer, within 10 feet of each side of the failing sample as determined by ENGINEER, until passing test locations are identified. Collect additional 2-foot long sample from each passing field test location and provide to ENGINEER for laboratory shear and peel testing.
 2. Repair field seam between passing test locations (based on field tensiometer results) by extrusion welding or patching.
 3. Non-destructively test patch or extrusion weld and repair, as required, until non-destructive test standards are achieved.
 4. If additional laboratory shear or peel tests fail, then additional destructive seam field samples will be collected and field tested to isolate failing seam, then laboratory tested.

5. Repeat above noted procedure until passing field and laboratory test results are achieved, thereby delineating extent of defective seam.
- K. Verification of Seams in Special Locations:
1. Non-destructively test seams in special locations (i.e., appurtenances) if seam is accessible to testing equipment. ENGINEER will observe all seam testing operations. If seam cannot be tested in place, it will be observed by ENGINEER and CONTRACTOR for uniformity and completeness.
 2. In the case of visual inspections, record the seam number, date of inspection, name of tester, and outcome of inspection.
 3. Promptly repair, retest, and re-mark defective seams to indicate completion of repair.
- L. Defects and Repairs:
1. Identification: Inspect seams and non-seam areas of geomembrane for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
 2. Evaluation: Non-destructively test each suspect location, both in seam and non-seam, using methods specified in Article 3.7. Mark and repair each location which fails non-destructive testing.
 3. Verification of Repairs: Non-destructively test each repair using the method specified in Article 3.7. Tests which pass non-destructive test standards will serve as an indication of an adequate repair. Re-repair and test failed test locations until a passing test results. Record the number of each repair, date, location, repair personnel initials, and test outcome. ENGINEER will observe non-destructive testing of repairs.
- M. Geomembrane Acceptance:
1. Geomembrane will be accepted by ENGINEER when:
 2. Installation is finished.
 3. Documentation of installation is completed and submitted to ENGINEER.
 4. Verification of the adequacy of field seams and repairs, and associated testing, is complete.
- N. Quality Assurance Testing: Quality assurance laboratory engaged by RACER will perform laboratory tests on geomembrane samples as identified in this Section to determine if geomembrane seams meet specified requirements. Copies of test reports will be supplied to CONTRACTOR on request. Retesting of previously failed geomembrane seams will be at no additional cost to RACER.

3.8 MANUFACTURER'S FIELD SERVICES

- A. Furnish services of a qualified manufacturer's representative to observe placement of geomembrane, subgrade preparation, geomembrane installation, and backfilling operations. Manufacturer's representative will provide guidance to installer on proper installation techniques, but will not assume liability or responsibility in overall installation.

3.9 CLEANING

- A. Section 01 00 00 - General Requirements: Requirements for cleaning.
- B. Remove construction debris from the Site and dispose in an environmentally responsible and legal manner.

3.10 PROTECTION

- A. Section 01 00 00 - General Requirements: Requirements for protection of installed work.
- B. Do not permit vehicular traffic directly on geomembrane. Cover overlying materials as indicated.
- C. Place soil cover layer from lower elevations to higher elevations. Push soil cover layer by traveling only on previously placed material, never directly on geomembrane, and by avoiding sudden turns or accelerations.

END OF SECTION

SECTION 33 41 00

DRAINAGE PIPING

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Subsurface perforated and solid wall drainage piping, including connections to catch basins.

1.2 RELATED SECTIONS

- A. Section 31 05 19.26 – Drainage Geocomposite.

1.3 PRICE AND PAYMENT PROCEDURES

- A. Measurement and Payment:
 - 1. Section 01 00 00 – General Requirements: Requirements for measurement and payment.
 - 2. 4-inch Dia. HDPE Perforated Pipe:
 - a. Schedule of Prices Item No. 33 41 16/1.
 - b. Measurement Basis: By the linear foot measured in place along centerline of pipe.
 - c. Payment Basis: Unit price. Includes supplying HDPE pipe, fittings, and accessories, and connection to pipe laterals.
 - 3. 4-inch Dia. HDPE Solid Wall Pipe Laterals:
 - a. Schedule of Prices Item No. 33 41 16/2.
 - b. Measurement Basis: By the linear foot measured in place along centerline of pipes.
 - c. Payment Basis: Unit price. Includes supplying HDPE pipe, fittings, and connection of pipe laterals to catch basins.

1.4 REFERENCES

- A. Section 01 00 00 - General Requirements: Requirements for references.
- B. Reference Standards:
 - 1. ASTM International:
 - a. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³)).
 - b. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
 - c. ASTM D3261 – Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
 - d. ASTM D3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
 - e. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

- f. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR)
Based on Outside Diameter.
- 2. State of Michigan: MDOT Drainage Manual.

1.5 PRE-INSTALLATION MEETING

- A. Section 01 00 00 - General Requirements: Pre-installation meeting.
- B. Convene minimum 1 week prior to commencing work of this Section.

1.6 SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for submittals.
- B. Shop Drawings: Provide construction details for laying pipe in perforated pipe trench and connection of laterals to catch basins.
- C. Product Data: Include for pipe materials, pipe fittings, and accessories.
- D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- E. Manufacturer's Instructions: Indicate special procedures required to install products specified. Submit manufacturer's installation instructions including jointing methods.
- F. Field Quality Control Submittals: Indicate results of CONTRACTOR-furnished tests and inspections.
- G. Qualifications Statement: Submit qualifications for manufacturer.

1.7 CLOSEOUT SUBMITTALS

- A. Section 01 00 00 - General Requirements: Requirements for closeout submittals.
- B. Record Documents: Accurately record actual locations of perforated pipe runs, lateral connections, and invert elevations.

1.8 QUALITY ASSURANCE

- A. Perform work of this Section in accordance with National Plumbing Code and applicable local code requirements.
- B. Regulatory Requirements: Conform to State of Michigan's MDOT Drainage Manual, Chapters 2 and 7.

1.9 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 10 years documented experience.

- B. Installer: Company specializing in performing the work of this Section with minimum 5 years documented experience.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 00 00 - General Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials according to manufacturer instructions.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 2. Provide additional protection according to manufacturer instructions.

1.11 WARRANTY

- A. Section 01 00 00 - General Requirements: Requirements for warranties.
- B. Provide 3-year manufacturer's warranty for all pipes and other materials.
- C. Fill out original warranty forms in OWNER's name and register with manufacturer.

1.12 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Verify field measurements prior to fabrication.
 - 2. Indicate field measurements on Record Drawings.

PART 2 PRODUCTS

2.1 PIPE

- A. HDPE Pipe: ASTM F714, ASTM D3035, ASTM D3350 for pressure rating SDR 11 Series, 4-inch diameter, perforated, 0.05-inch slot width, 1.75-inch ID slot length, and 0.5-inch slot spacing, as shown on Drawings.
- B. Fittings: HDPE, ASTM D3350 and ASTM F 714.
- C. Joints: ASTM D3261 Technique II: Butt fusion.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Section 01 00 00 - General Requirements: Verification of existing conditions before starting work.
- B. Verify that excavation base is ready to receive work and excavations, dimensions, and elevations are as shown on the Drawings.
- C. Obtain approval from ENGINEER for completed excavation prior to placing bedding material or piping.

3.2 PREPARATION

- A. Remove large stones or other hard matter which could damage piping or impede consistent backfilling or compaction.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare pipe connections to equipment with flanges or unions.
- D. Clean pipe of accumulated debris and water before installation.
- E. Carefully inspect materials for defects and remove defective materials from the Site.

3.3 PIPE INSTALLATION

- A. Install pipe in accordance with manufacturer's instructions and ASTM D2321 to indicated elevations to within tolerance of 0.5 inch.
- B. Seal joints watertight.
- C. After completion of any section of pipe, the grades, joints, and alignment shall be true to line and grade. There shall be no visual leakage and the piping system shall be completely free from any cracks.
- D. Record the depth of pipe invert elevations. Generate and maintain on the Site an as built profile of the pipe installation.
- E. Backfill around pipes shall be placed in a manner which will prevent damage to the pipe and which will allow the pipe to assume the loads from the fill gradually and uniformly.

3.4 FIELD QUALITY CONTROL

- A. Section 01 00 00 - General Requirements: Field inspecting and testing.
- B. Perform compaction testing in accordance with ASTM D698. Due to the shallow depth of cover, HDPE profile pipe shall not be subject to roller or wheel loads over top of the pipe.

- C. Testing Frequency: Once upon completion of installation.

3.5 CLEANING

- A. Section 01 00 00 - General Requirements: Requirements for cleaning.
- B. On completion of testing, clean pipes by flushing; supplement flushing by use of mechanical equipment as necessary to remove foreign material from the pipe.
- C. Notify ENGINEER at least 24 hours prior to commencing flushing.
- D. Provide connections and pumps as required for flushing operations.

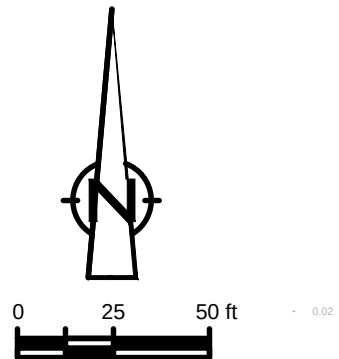
3.6 PROTECTION

- A. Section 01 00 00 - General Requirements: Requirements for protection of installed work.
- B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

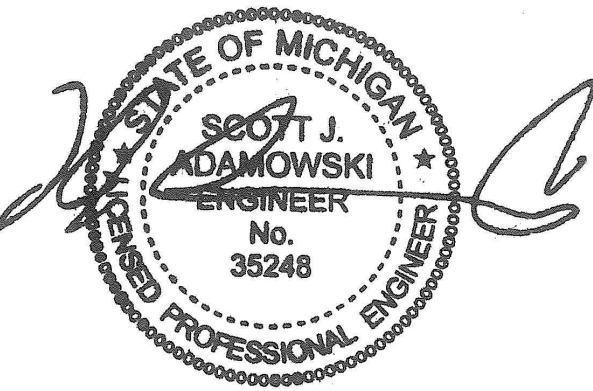
END OF SECTION

Appendix B

Design Drawings



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LEGEND	
	EXISTING SLURRY WALL
	PERFORATED PIPE TRENCH
	LINER ANCHOR TRENCH
	PROPOSED FRENCH DRAIN
	PROPOSED DISCHARGE LINE
	EXISTING FRENCH DRAIN TO BE PROTECTED
	MW-A2-2S EXISTING MONITORING WELL/ PERFORMANCE MONITORING LOCATION TO BE PROTECTED BY CONTRACTOR
	MW-86S-20 PROPOSED NEW MONITORING WELL/ PERFORMANCE MONITORING LOCATION TO BE INSTALLED BY GHD AND TO BE ACCOUNTED FOR DURING LINER INSTALLATION BY CONTRACTOR
	MW-95S-20 PROPOSED NEW MONITORING WELL/ PERFORMANCE MONITORING LOCATION TO BE INSTALLED AHEAD OF LINER BY GHD AND TO BE ACCOUNTED FOR DURING LINER INSTALLATION BY CONTRACTOR
	PROPOSED NEW MANHOLE
	PROPOSED NEW CLEANOUT

Client
RACER TRUST

Project
**13000 ECKLES ROAD SITE
LIVONIA, MICHIGAN
LINER SYSTEM DESIGN**

5	ADDENDUM 4	MS	RH	07-28-2021
4	ADDENDUM 3	MS	RH	07-09-2021
3	ADDENDUM 2	MS	RH	05-14-2021
2	ADDENDUM 1	MS	RH	02-26-2021
1	BID	MS	RH	02-18-2021
No.	Issue	Drawn	Approved	Date

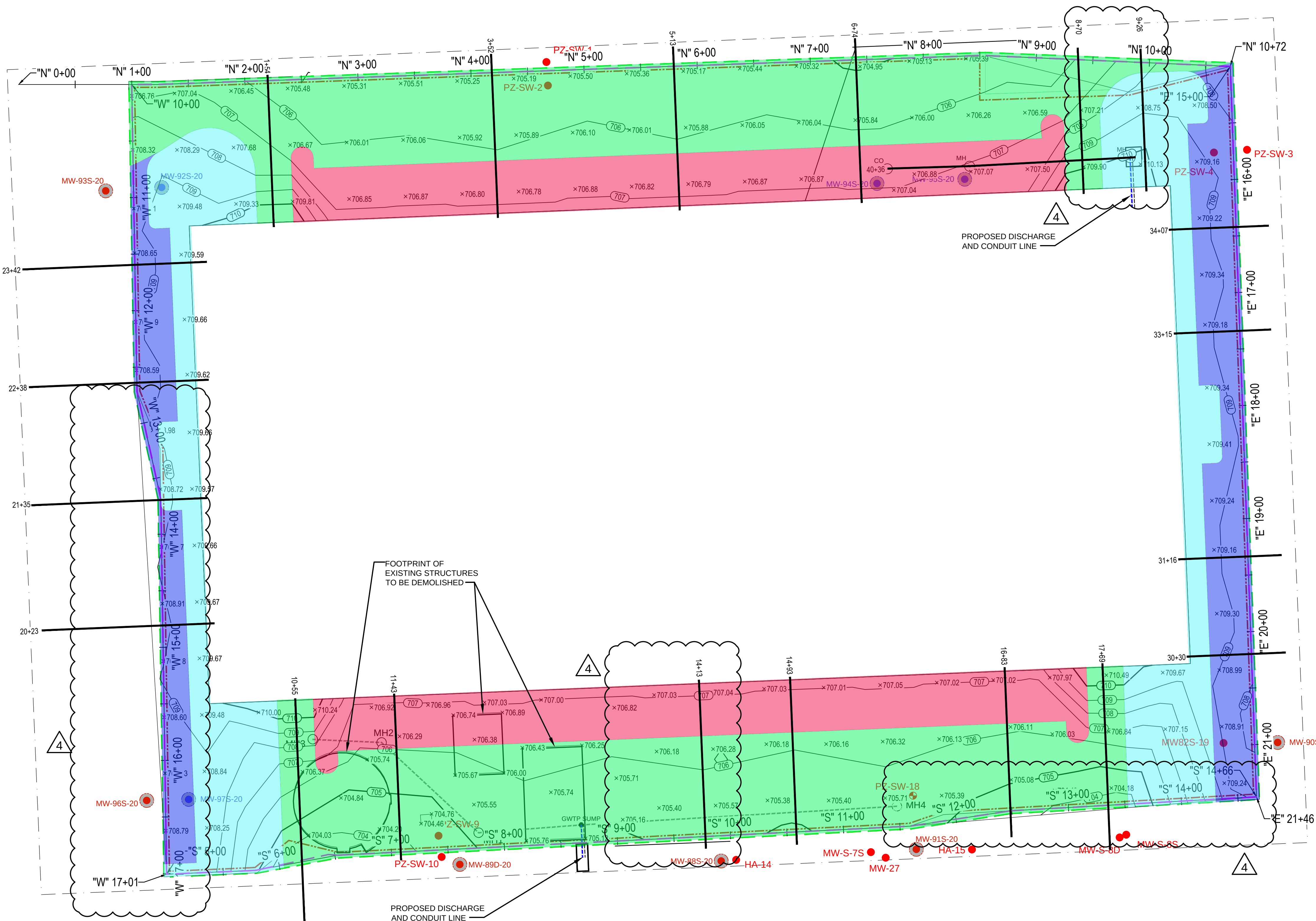
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ANSI D			

Project No. 012607-01

Title
**OVERALL SUBGRADE
PLAN**

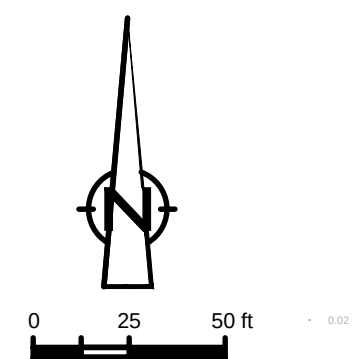
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FIGURE 1



SUBGRADE LEGEND	
	MAINTAIN 13" BELOW CURRENT GRADE
	MAINTAIN 16" BELOW CURRENT GRADE
	CONTINUE 13.5" BELOW CURRENT GRADE ELEVATION FROM CONCRETE AREA
	MAINTAIN 13.5" BELOW CURRENT GRADE

REFER TO FIGURE 2.1 FOR TRENCH
PROFILE DRAWINGS



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LEGEND

---	EXISTING SLURRY WALL
---	PERFORATED PIPE TRENCH
---	LINER ANCHOR TRENCH
---	PROPOSED FRENCH DRAIN
---	PROPOSED DISCHARGE LINE
---	EXISTING FRENCH DRAIN TO BE PROTECTED

RACER TRUST

13000 ECKLES ROAD SITE LIVONIA, MICHIGAN LINER SYSTEM DESIGN

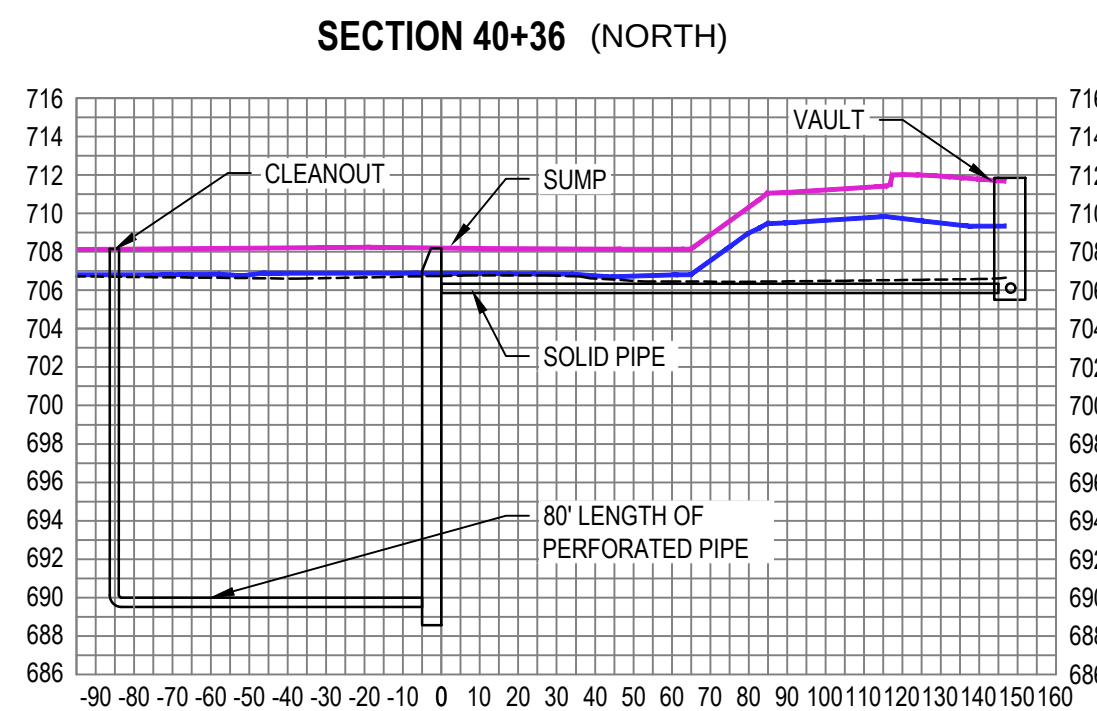
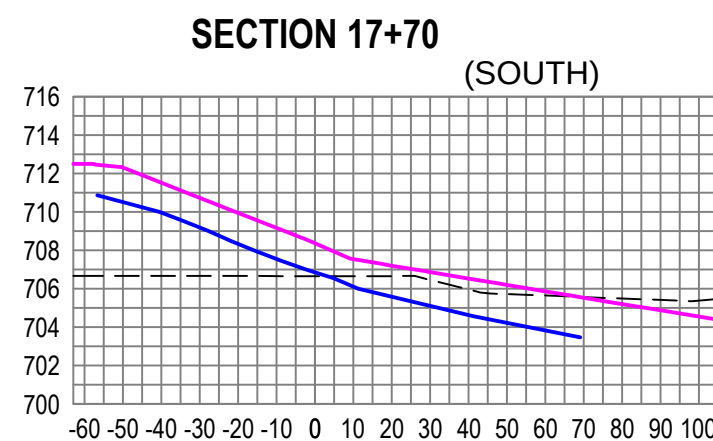
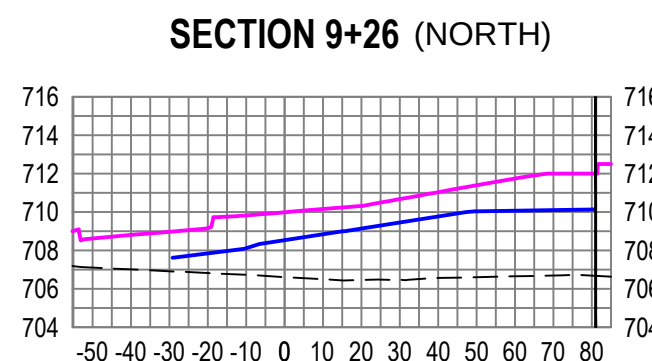
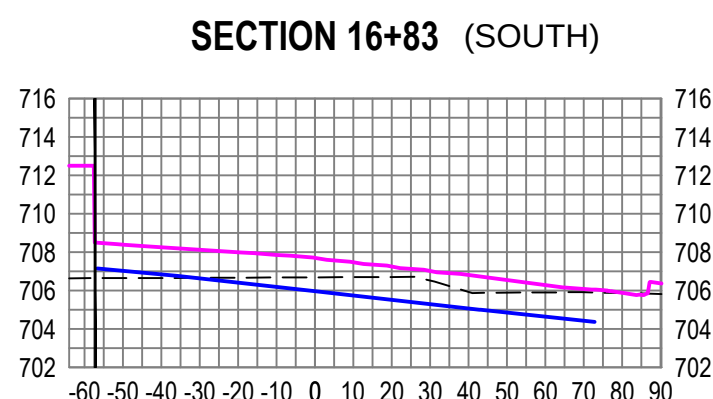
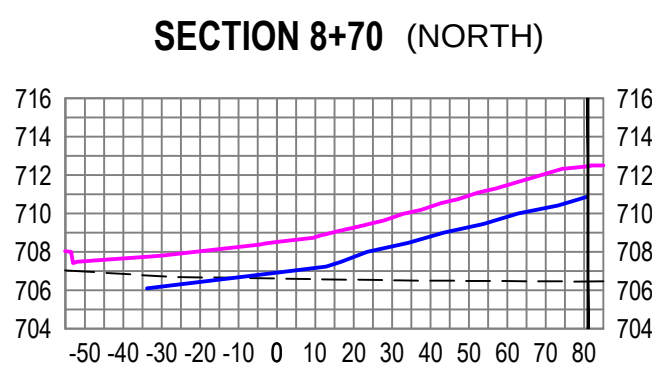
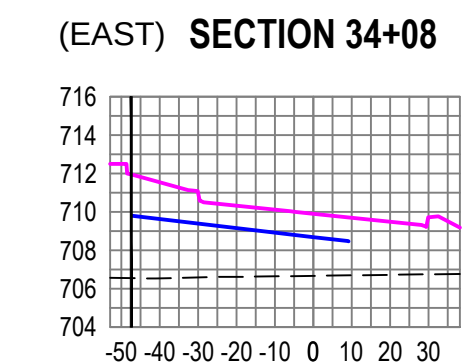
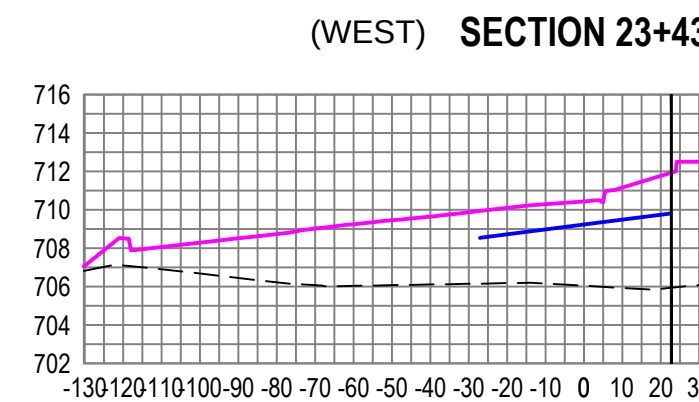
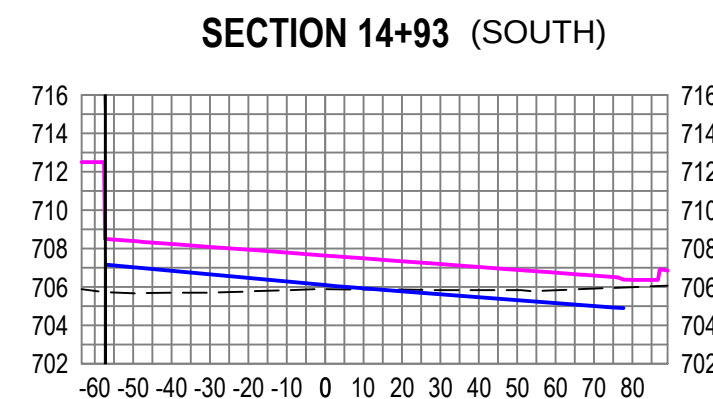
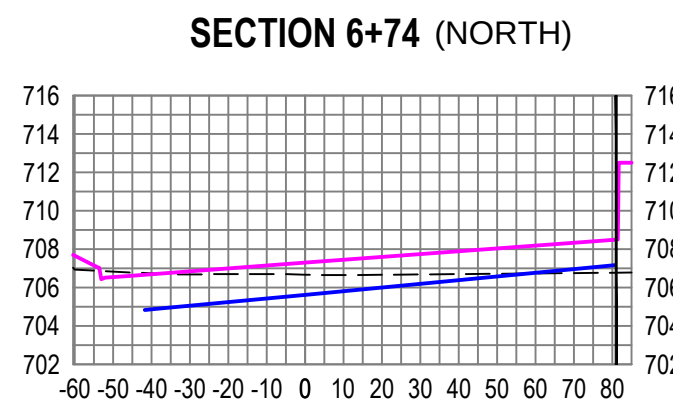
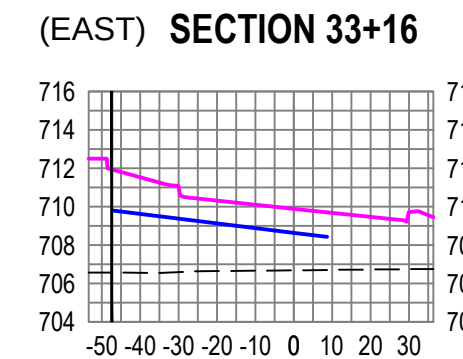
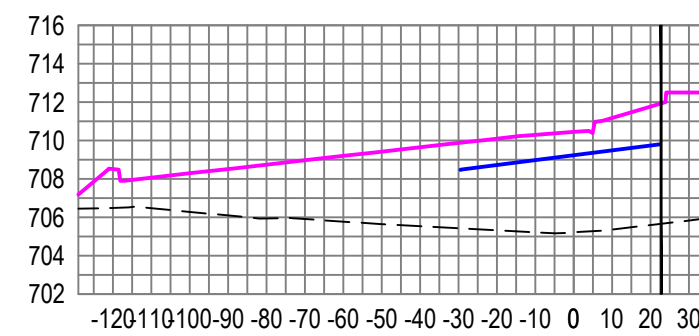
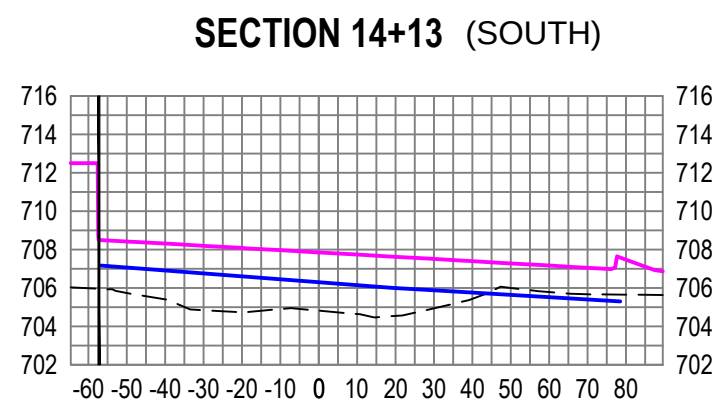
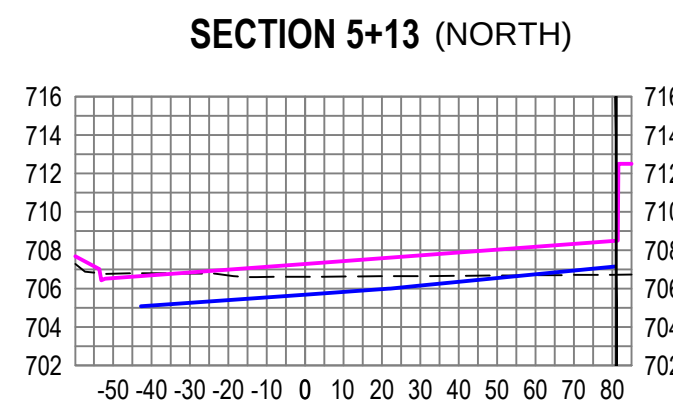
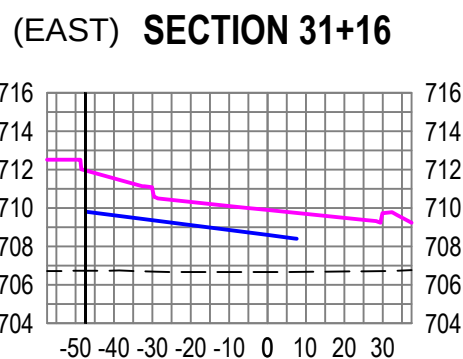
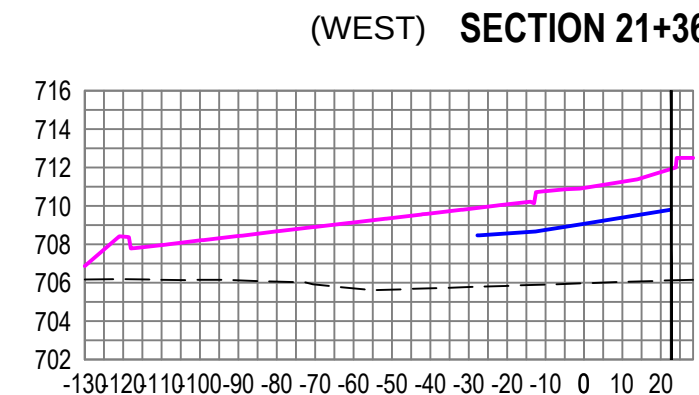
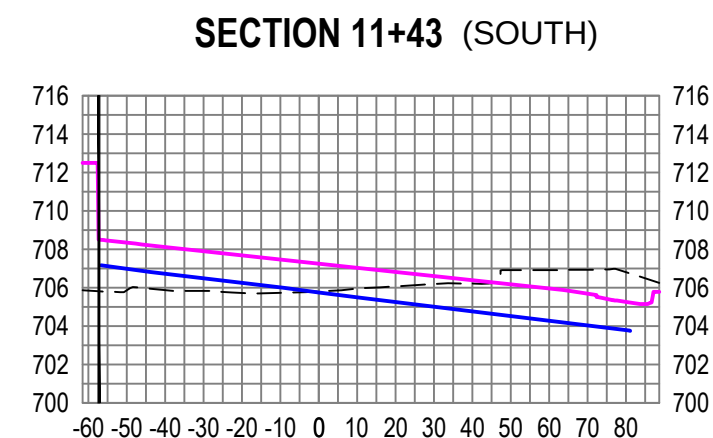
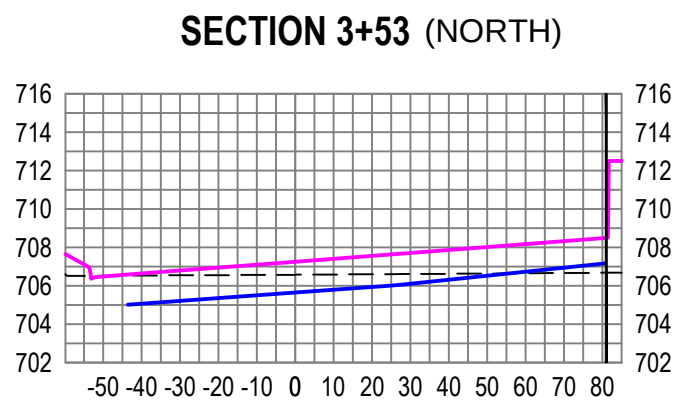
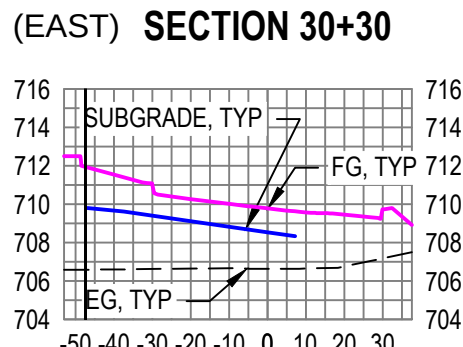
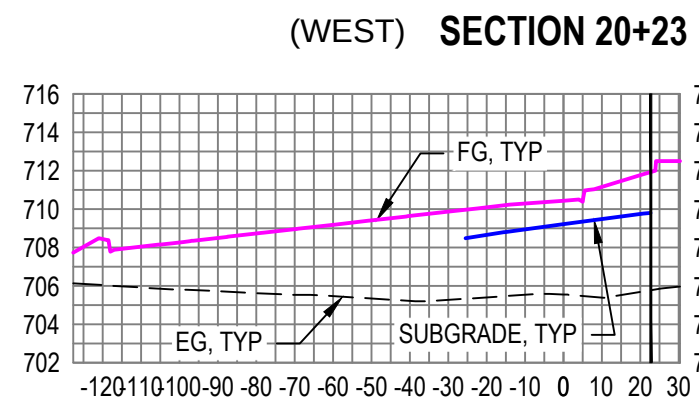
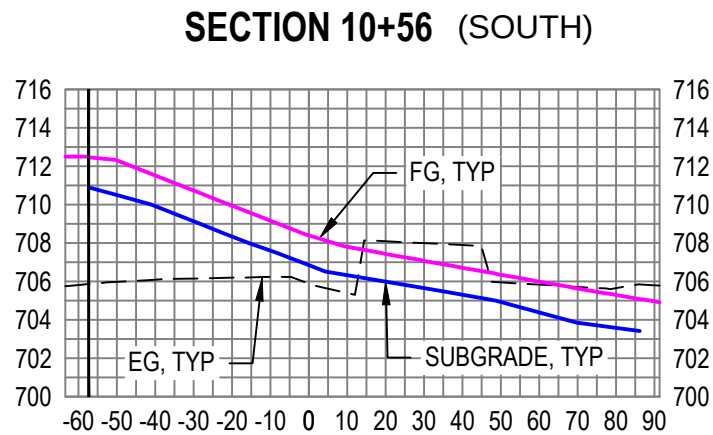
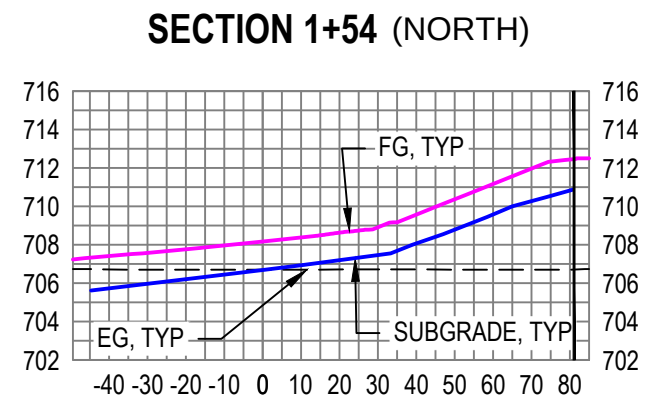
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Drafting Check RH	Design Check SA
Project Manager CM	Date Aug 12, 2021
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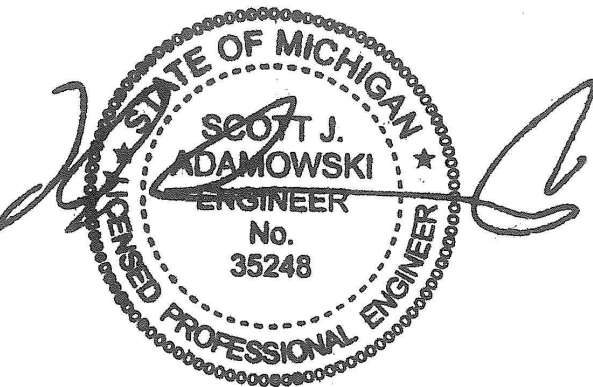
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**PROFILE LEGEND
AND STATIONING**

FIGURE 1.1



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LEGEND
— FINAL GRADE
— PROPOSED SUBGRADE
- - - EXISTING GROUND



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Project
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LIVONIA, MICHIGAN
LINER SYSTEM DESIGN**

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3	ADDENDUM 2	MS	RH	05-14-2021
2	ADDENDUM 1	MS	RH	02-26-2021
1	BID	MS	RH	02-18-2021

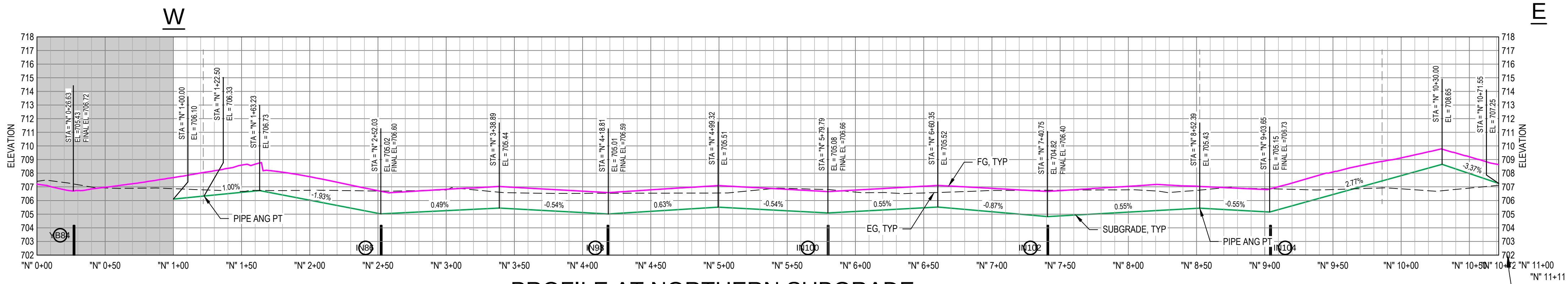
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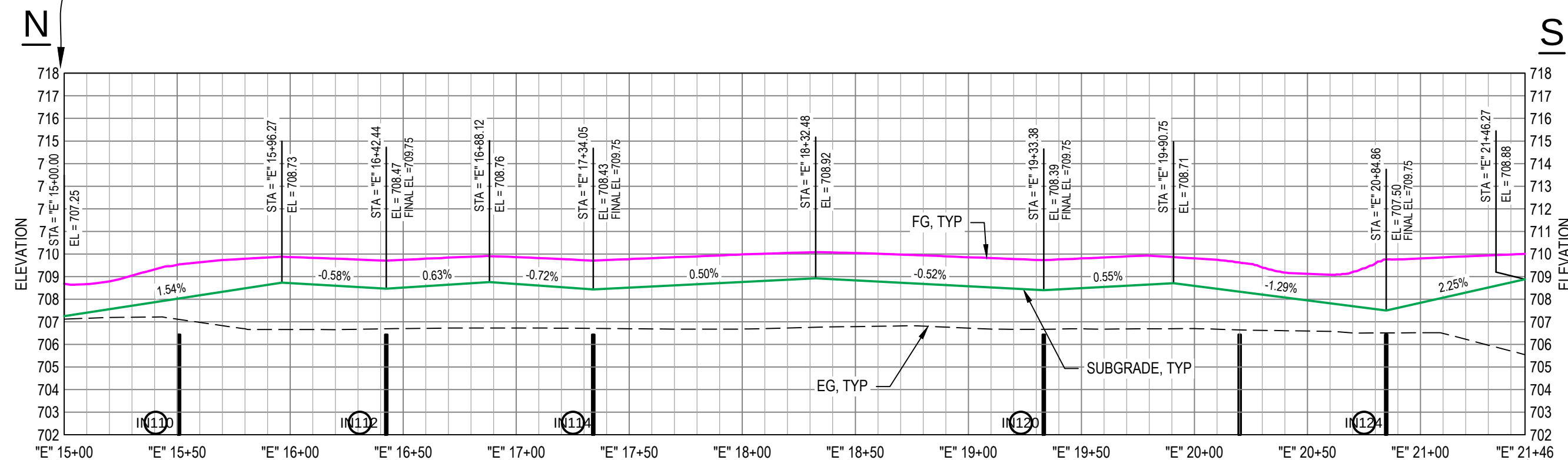
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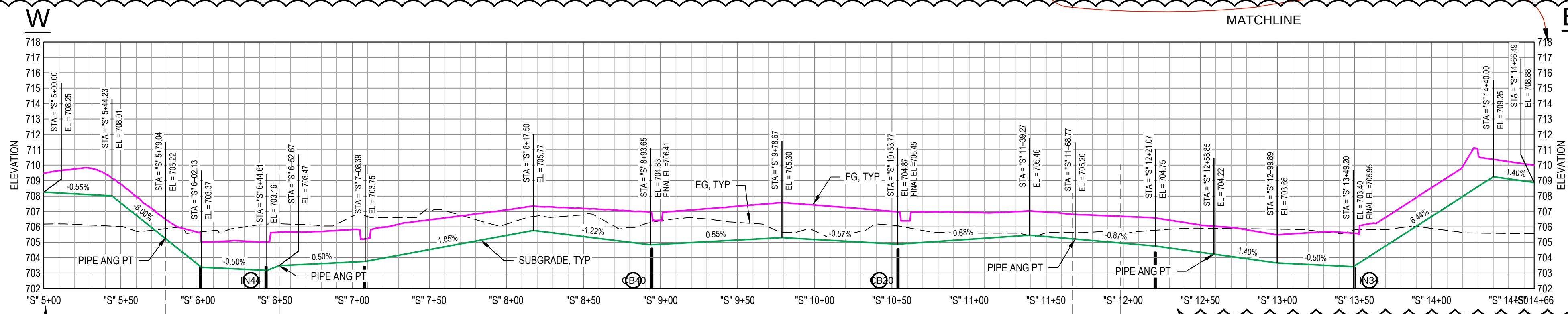
FIGURE 2



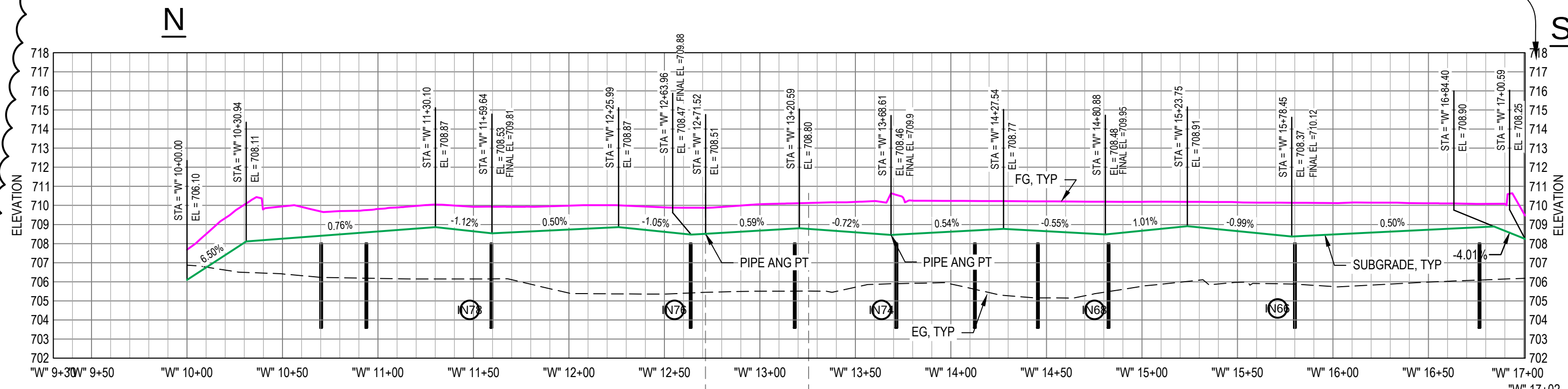
PROFILE AT NORTHERN SUBGRADE



PROFILE AT EASTERN SUBGRADE



PROFILE AT SOUTHERN SUBGRADE



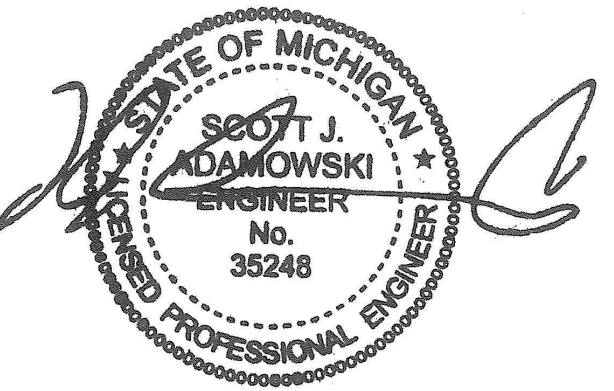
PROFILE AT WESTERN SUBGRADE

NOTE:

REFER TO FIGURE 1.1 FOR PIPE TRENCH STATIONING



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LEGEND

- FINAL GRADE
- SUBGRADE
- EXISTING GROUND
- N SOLID PIPE LATERALS DESIGNATION



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Project

**13000 ECKLES ROAD SITE
LIVONIA, MICHIGAN
LINER SYSTEM DESIGN**

No.	Issue	Drawn	Approved	Date
5	ADDENDUM 4	MS	RH	07-28-2021
4	ADDENDUM 3	MS	RH	07-09-2021
3	ADDENDUM 2	MS	RH	05-14-2021

Drawn	MS	Designer	RH
Drafting Check	RH	Design Check	SA
Project Manager	CM	Date	Aug 12, 2021
Original Size	Scale AS SHOWN		

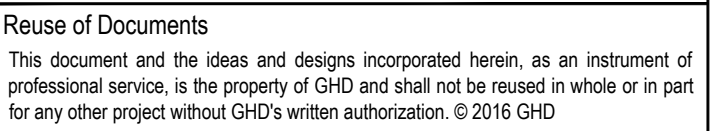
Project No. **012607-01**

Title
TRENCH PROFILES

Sheet No.

FIGURE 2.1

Lateral	Top of Catch Basin	Invert at Trench	Invert at Catch Basin	Depth to Pipe Invert	Lateral Length	Connection Location at Catch Basin	Slope Degrees
YB84	706.70'	705.51'	703.62'	3.10'	67.0'	SE	1.62
IN86	706.37'	704.02'	703.29'	3.08'	9.26'	SW	4.51
IN98	706.37'	704.01'	703.32'	3.05'	8.5'	S	4.64
IN100	706.43'	704.08'	703.35'	3.08'	9.5'	S	4.39
IN102	706.43'	703.82'	703.41'	3.02'	10.5'	S	2.24
IN104	706.50'	704.15'	703.40'	3.10'	15.4'	SE	2.79
IN110	709.23'	706.25'	704.92'	4.31'	54.0'	NW	1.41
IN112	709.22'	707.47'	706.18'	3.04'	20.0'	W	3.69
IN114	709.22'	707.43'	706.14'	3.08'	20.0'	W	3.60
IN120	709.22'	707.39'	705.52'	3.70'	22.0'	W	4.86
IN124	709.23'	706.50'	705.07'	4.00'	22.5'	W	3.64
IN34	704.40'	702.43'	701.36'	4.16'	36.62'	NW	1.67
CB20	706.37'	703.87'	703.33'	3.04'	7.75'	NW	3.99
CB40	706.29'	703.83'	703.22'	3.07'	6.0'	NW	5.81
IN44	705.00'	702.16'	702.01'	3.01'	1.0'	NE	8.53
IN66	707.82'	707.49'	704.51'	3.31'	100.04'	E	1.99
IN68	707.79'	707.70'	704.74'	3.05'	102.52'	E	1.65
IN74	707.78'	708.26'	704.74'	3.04'	104.50'	E	1.93
IN76	707.89'	707.47'	704.72'	3.17'	86.5'	E	1.78
IN78	707.89'	707.53'	704.79'	3.10'	91.0'	E	1.72



LEGEND

- EXISTING SLURRY WALL
- PERFORATED PIPE TRENCH
- LINER ANCHOR TRENCH
- PROPOSED FRENCH DRAIN
- PROPOSED DISCHARGE LINE
- EXISTING FRENCH DRAIN TO BE PROTECTED
- EXISTING MONITORING WELL
- PERFORMANCE MONITORING LOCATION TO BE PROTECTED BY CONTRACTOR
- EXISTING MONITORING WELLS TO BE HANDLED BY GHD
- PROPOSED NEW MONITORING WELL / PERFORMANCE MONITORING LOCATION TO BE INSTALLED BY GHD
- TO BE ACCOUNTED FOR DURING LINER INSTALLATION BY CONTRACTOR
- PROPOSED NEW MANHOLE
- PROPOSED NEW CLEANOUT
- SOLID PIPE LATERALS
- SOLID PIPE LATERALS DESIGNATION
- STORM LINES
- PROPOSED NEW MONITORING WELL / PERFORMANCE MONITORING LOCATION TO BE INSTALLED AHEAD OF LINER BY GHD AND TO BE ACCOUNTED FOR DURING LINER INSTALLATION BY CONTRACTOR

Client

RACER TRUST

Project

13000 ECKLES ROAD SITE LIVONIA, MICHIGAN LINER SYSTEM DESIGN

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No.	Issue	Drawn	Approved	Date

Drawn	MS	Designer	RH
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Drafting	RH	Design	SA
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Project CM	Date Jul 29, 2021
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Original Size	
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ANSI D original size drawing
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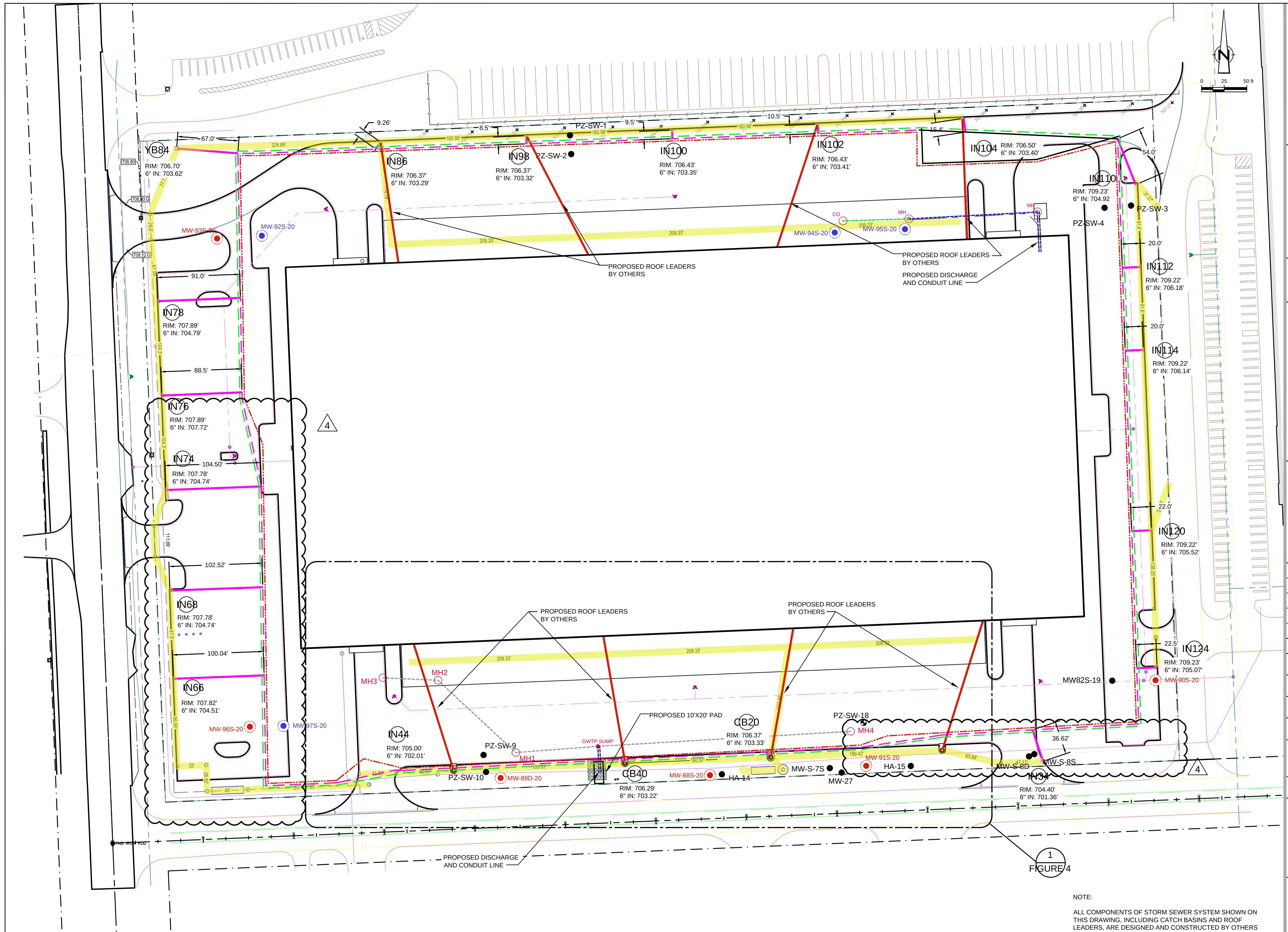
Project No. _____

Title

OVERALL DRAINAGE PIPING PLAN

Sheet No.

FIGURE 3



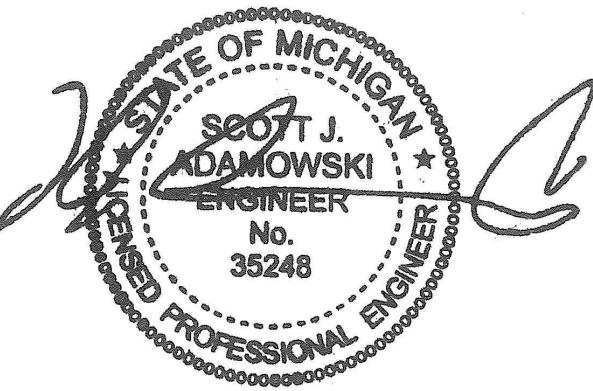
NOTE:

ALL COMPONENTS OF STORM SEWER SYSTEM SHOWN ON THIS DRAWING, INCLUDING CATCH BASINS AND ROOF LEADERS, ARE DESIGNED AND CONSTRUCTED BY OTHERS





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- LEGEND**
- EXISTING SLURRY WALL
 - PERFORATED PIPE TRENCH
 - LINER ANCHOR TRENCH
 - PROPOSED FRENCH DRAIN
 - PROPOSED DISCHARGE LINE
 - EXISTING FRENCH DRAIN TO BE PROTECTED
 - EXISTING MONITORING WELL/ PERFORMANCE MONITORING LOCATION TO BE PROTECTED BY CONTRACTOR
 - EXISTING MONITORING WELL/ TO BE ABANDONED BY GHD
 - PROPOSED NEW MONITORING WELL/ PERFORMANCE MONITORING LOCATION TO BE INSTALLED BY GHD AND TO BE ACCOUNTED FOR DURING LINER INSTALLATION BY CONTRACTOR
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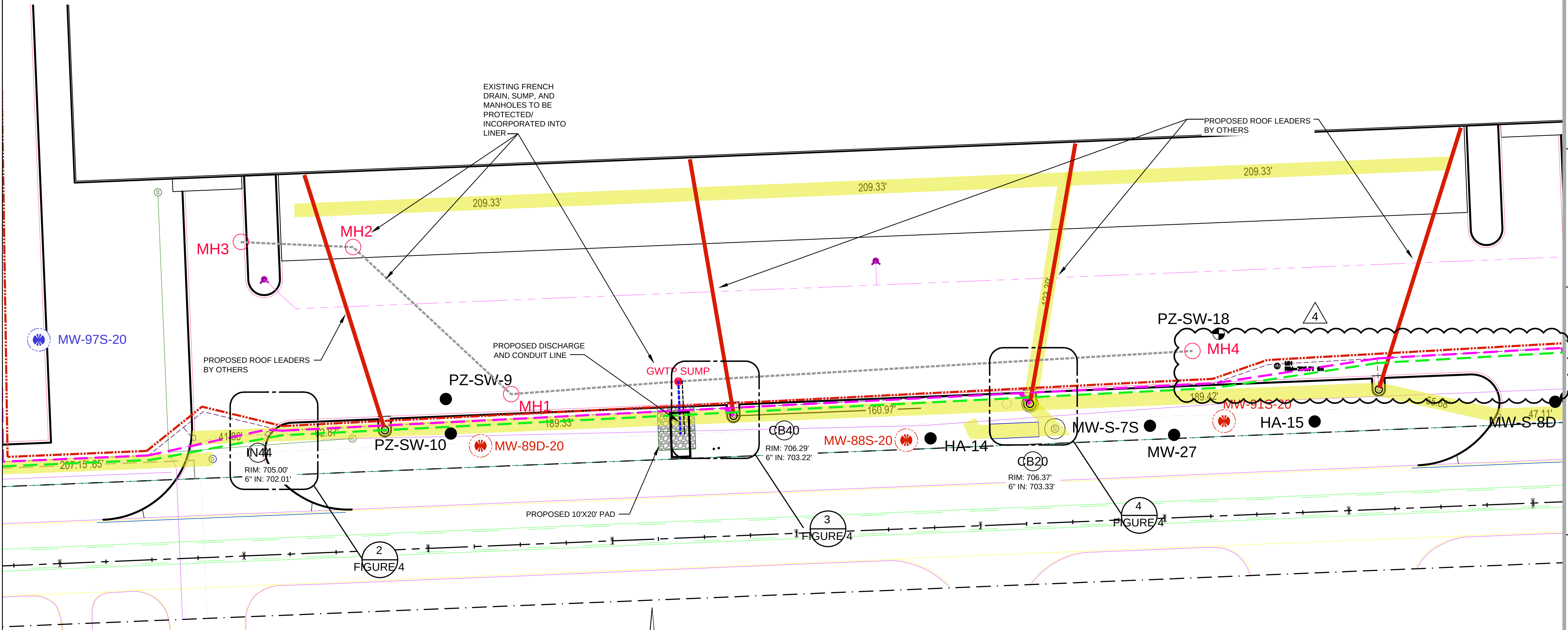
Drawn	MS	Designer	RH
Drafting Check	RH	Design Check	SA
Project Manager	CM	Date	Jul 29, 2021
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Original Size	ANSI D		
		Bar is one inch on original size drawing 0 1"	

Project No.

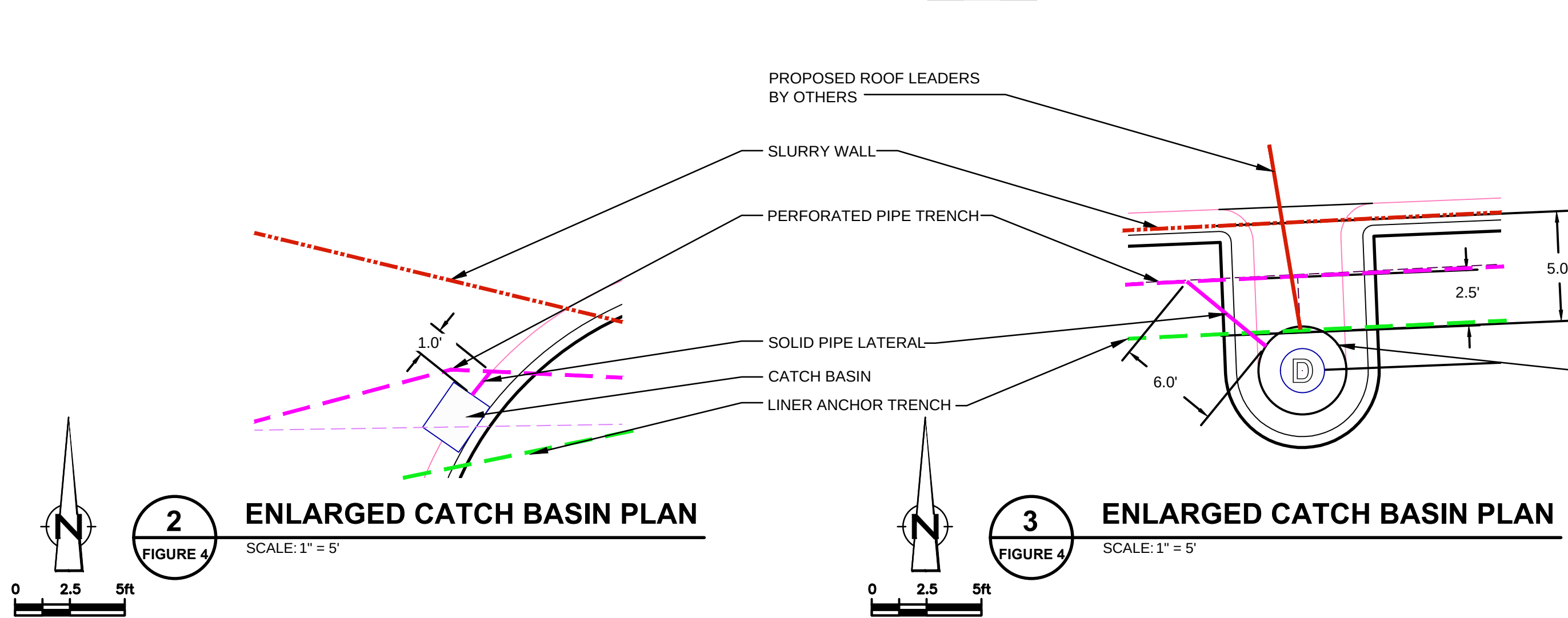
Title
ENLARGED SOUTH DRAINAGE PIPING PLAN

Sheet No.

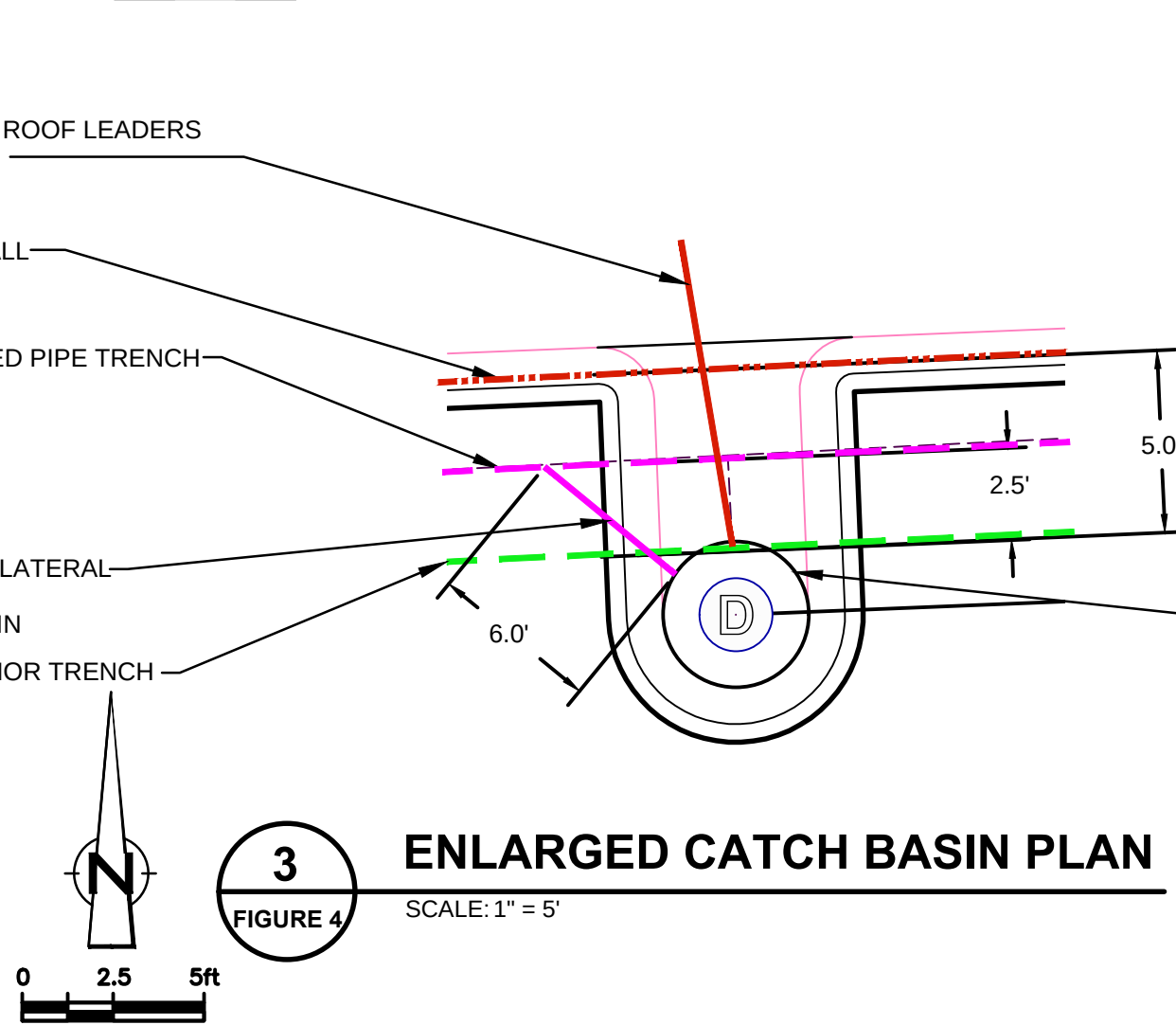
FIGURE 4



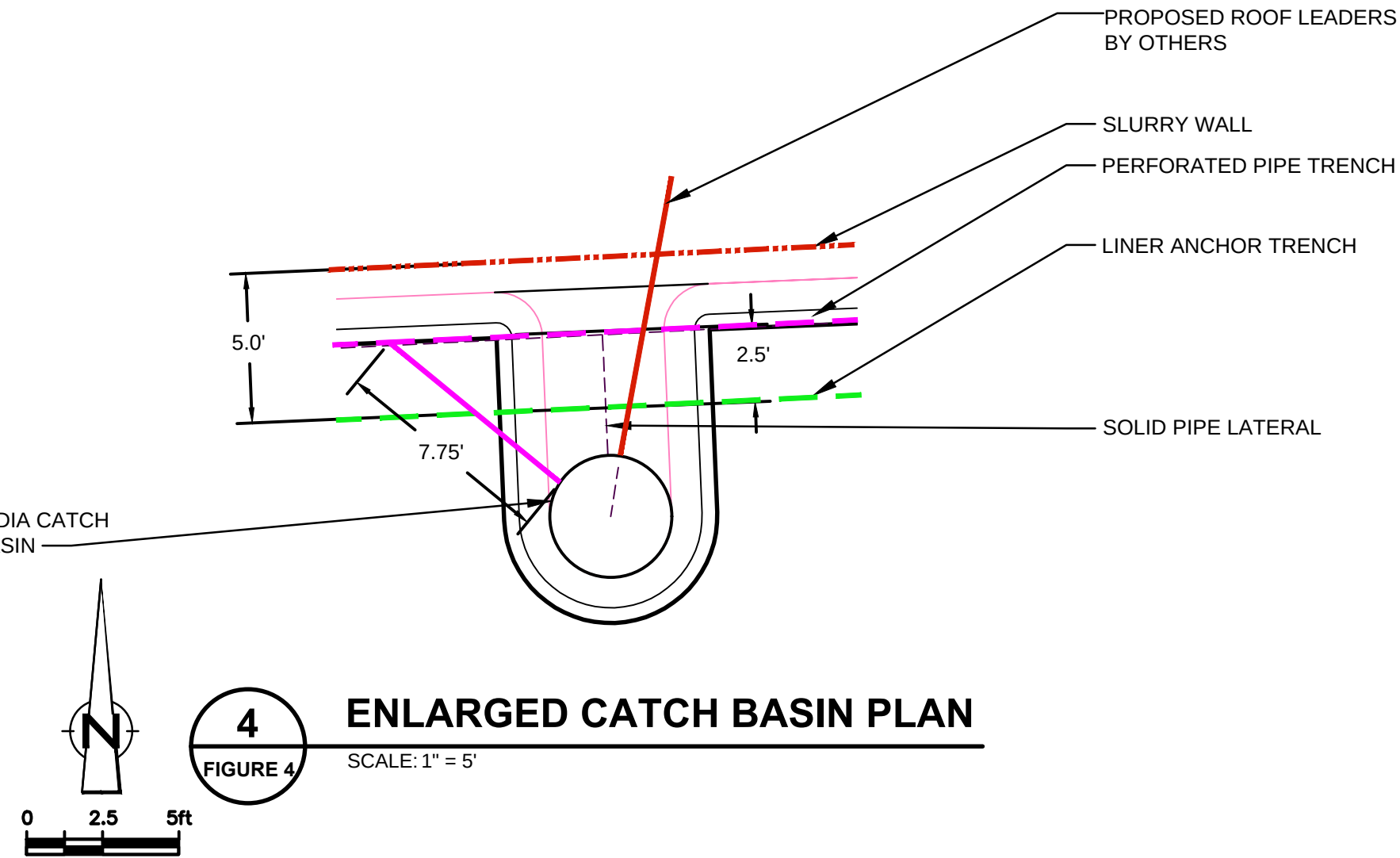
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ENLARGED SOUTH DRAINAGE PIPING PLAN
SCALE: 1" = 30'
FIGURE 4



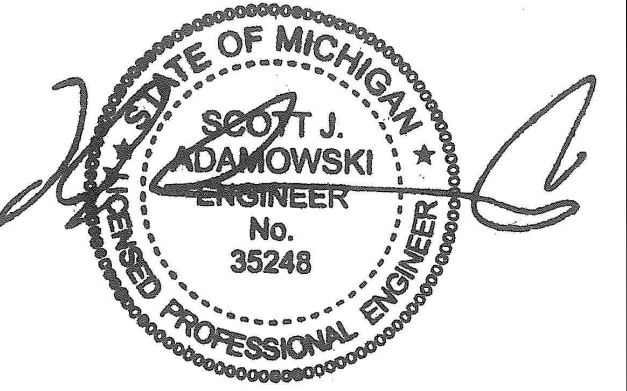
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ENLARGED CATCH BASIN PLAN
SCALE: 1" = 5'
FIGURE 4



3
ENLARGED CATCH BASIN PLAN
SCALE: 1" = 5'
FIGURE 4



4
ENLARGED CATCH BASIN PLAN
SCALE: 1" = 5'
FIGURE 4



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LEGEND

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- LINER ANCHOR TRENCH
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- PROPOSED DISCHARGE LINE
- EXISTING FRENCH DRAIN TO BE PROTECTED
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Drafting Check	RH	Design Check	SA
Project Manager	CM	Date	Jul 29, 2021

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Original Size	Bar is one inch on original size drawing
ANSI D	0

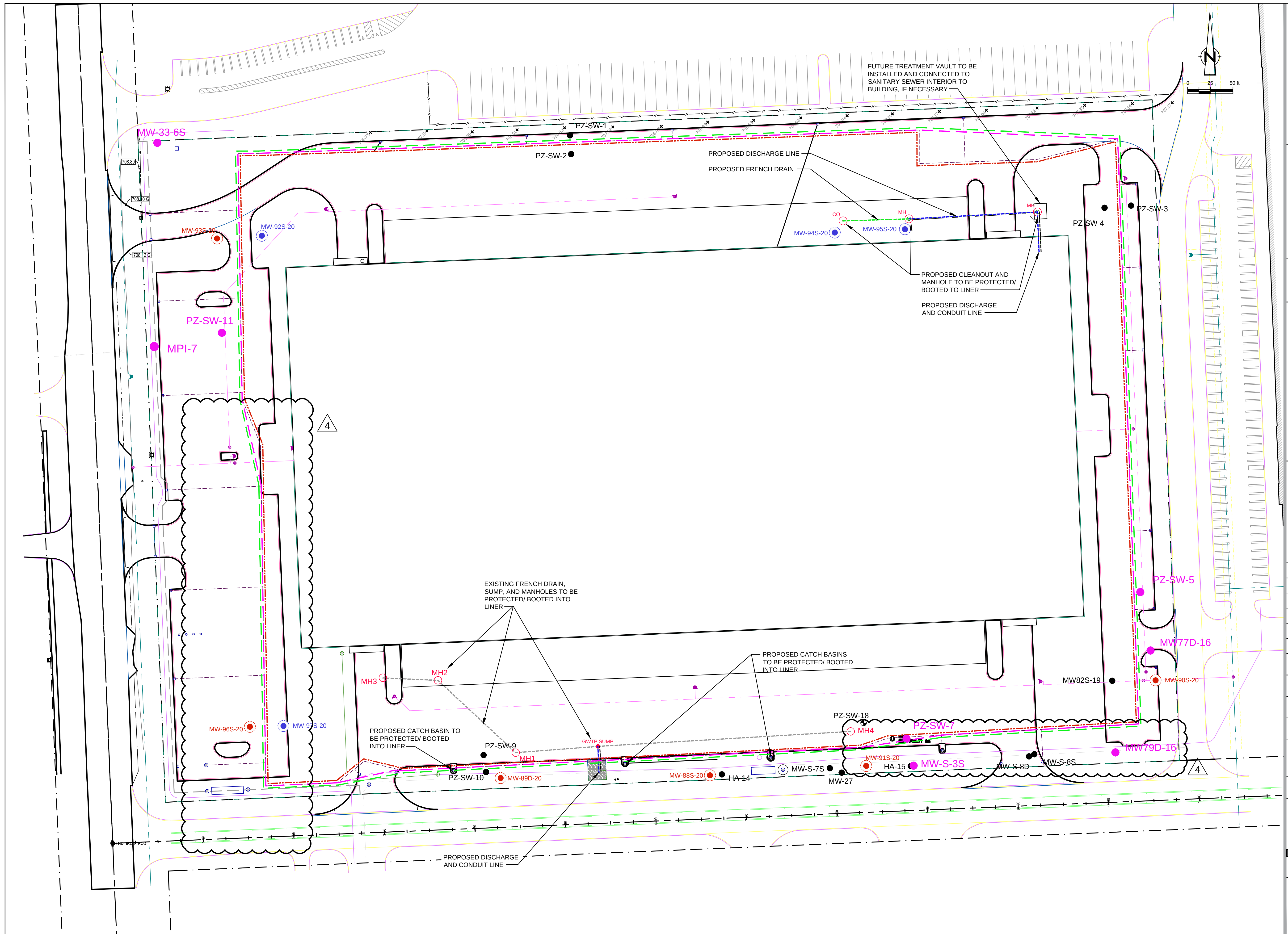
Project No.

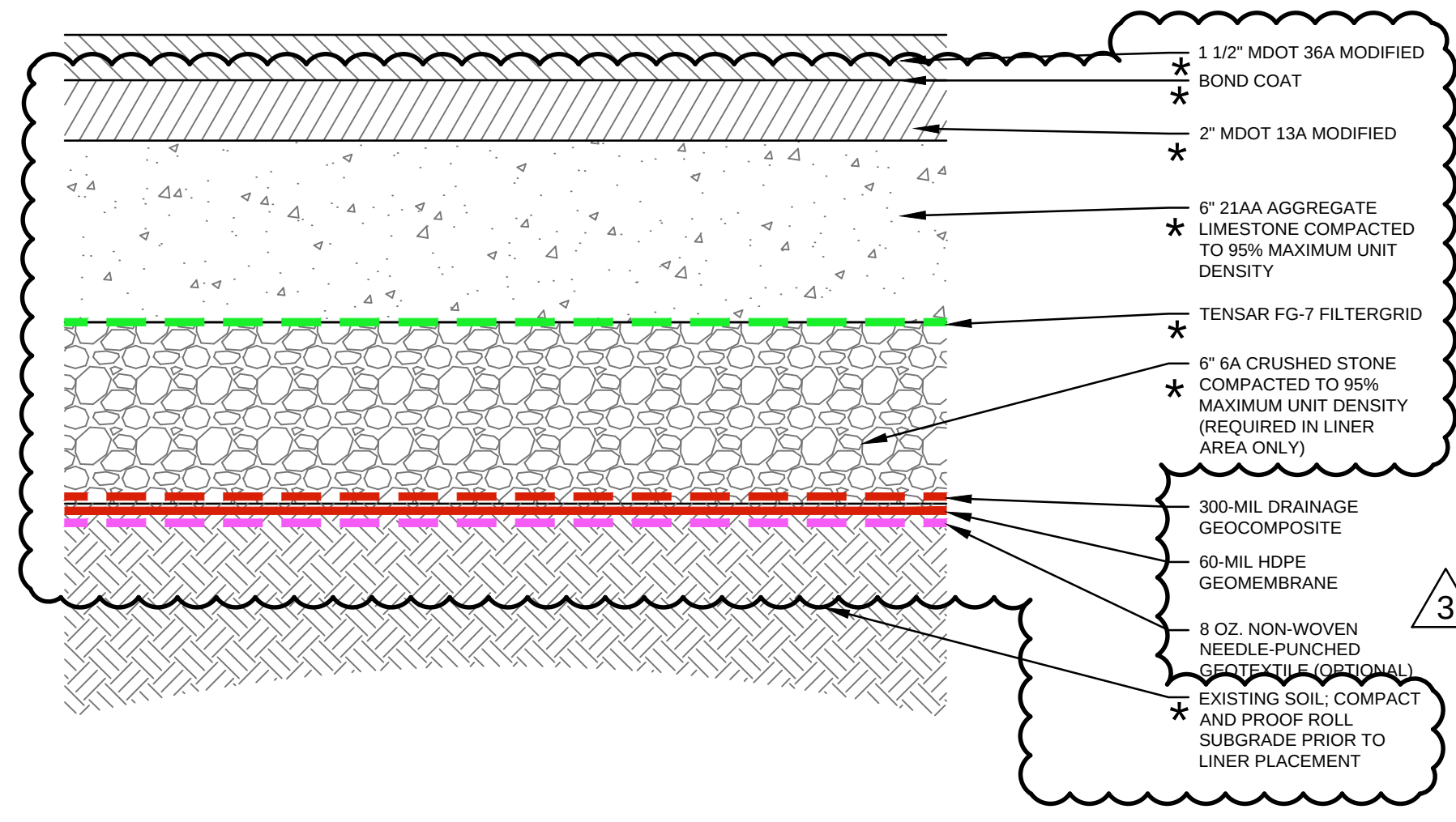
Title

**MONITORING WELLS AND SITE
FEATURES TO BE PROTECTED
DURING CONSTRUCTION ACTIVITIES**

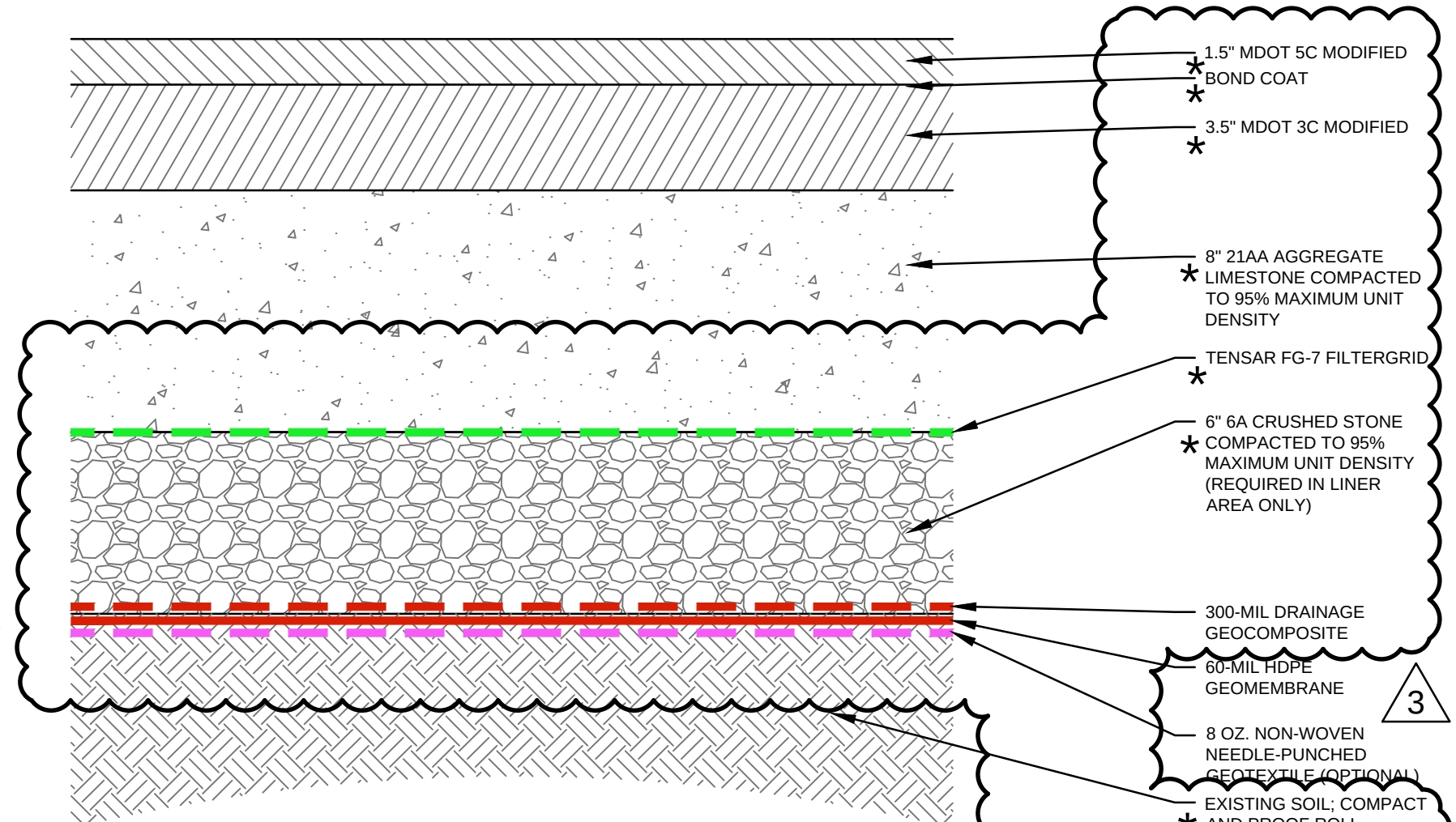
Sheet No.

FIGURE 5

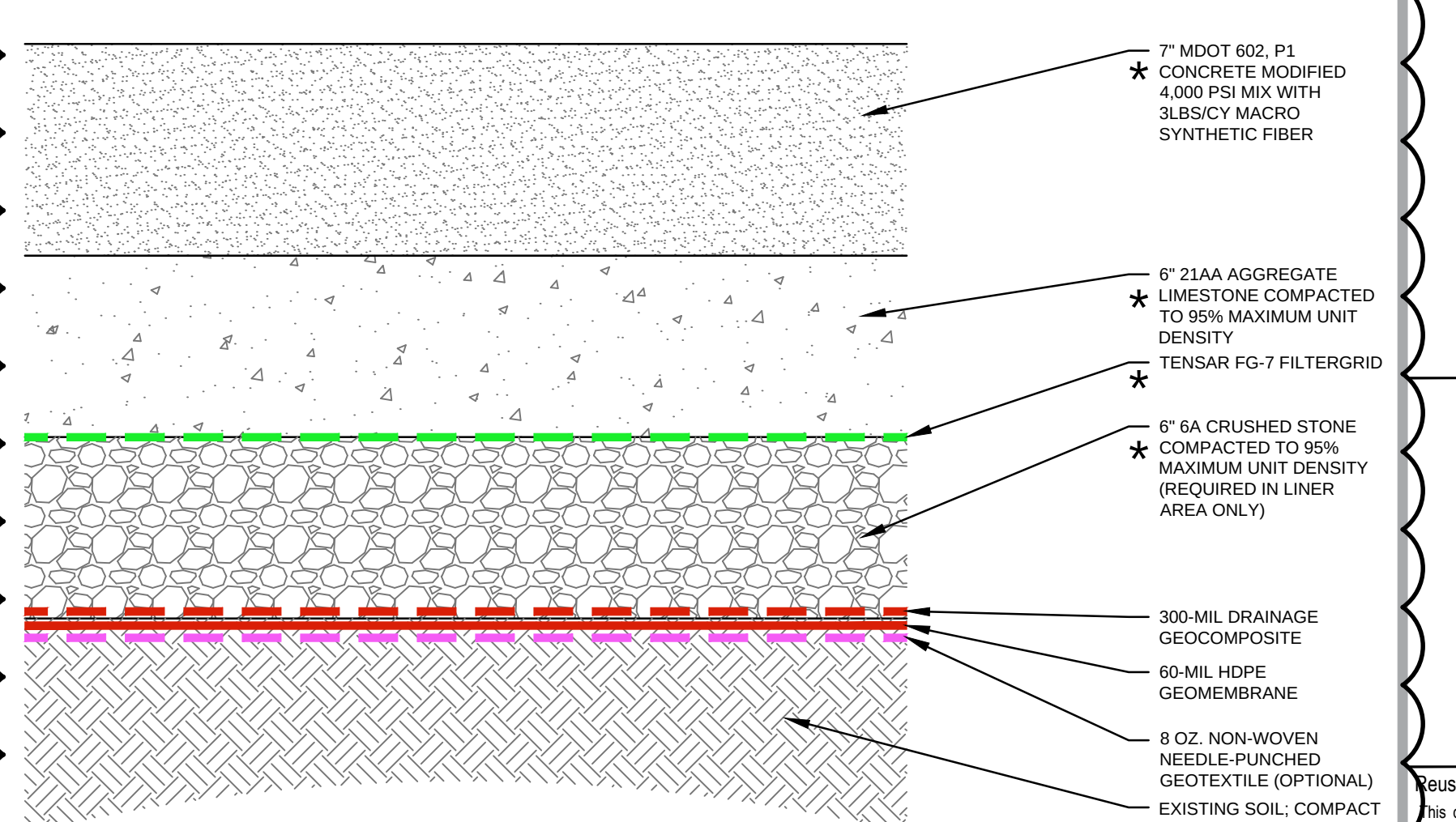




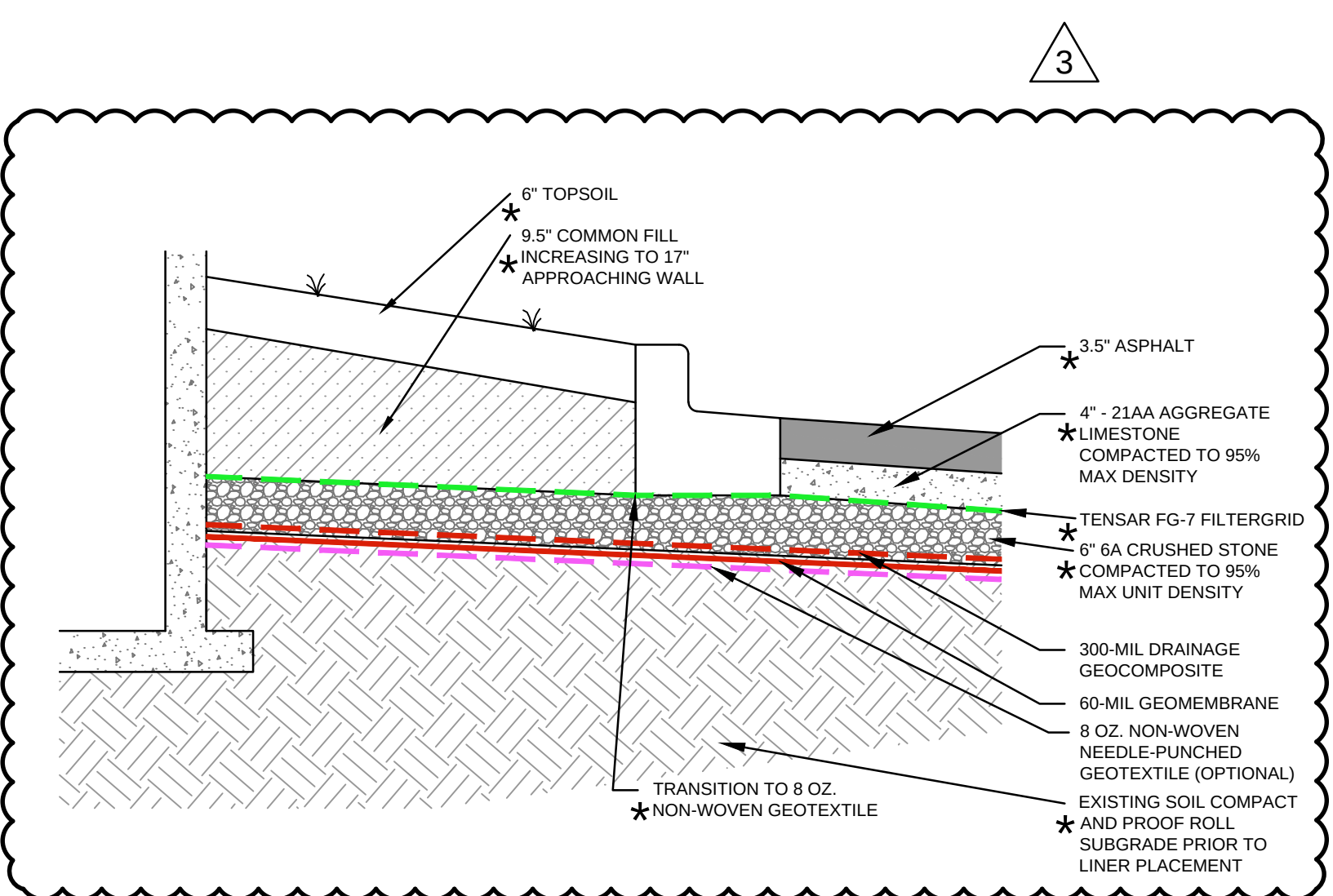
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FIGURE 6
LIGHT BITUMINOUS PAVING SECTION (CAR AREAS)
SCALE: NOT TO SCALE



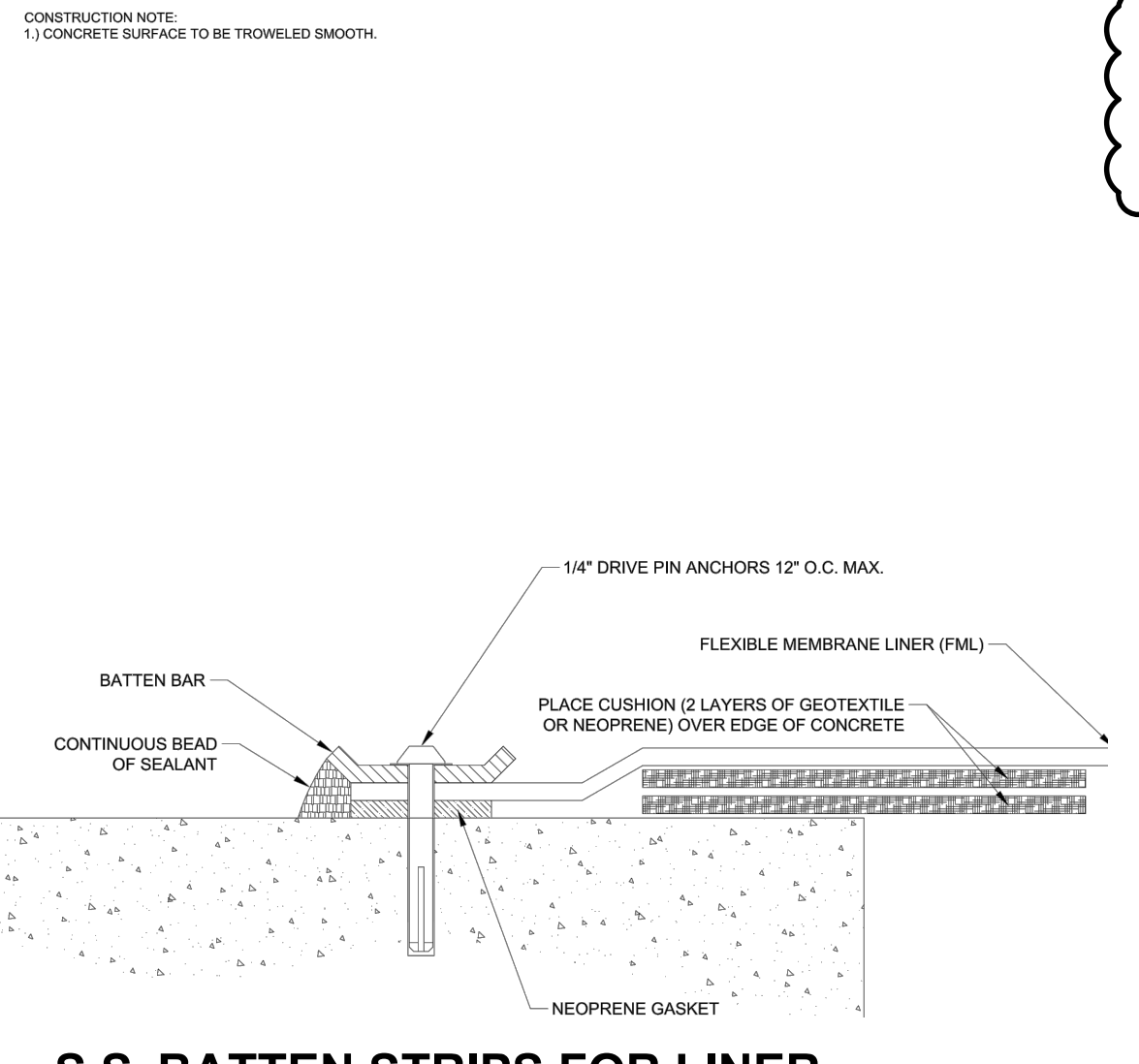
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FIGURE 6
HEAVY BITUMINOUS PAVING SECTION (TRUCK AREAS)
SCALE: NOT TO SCALE



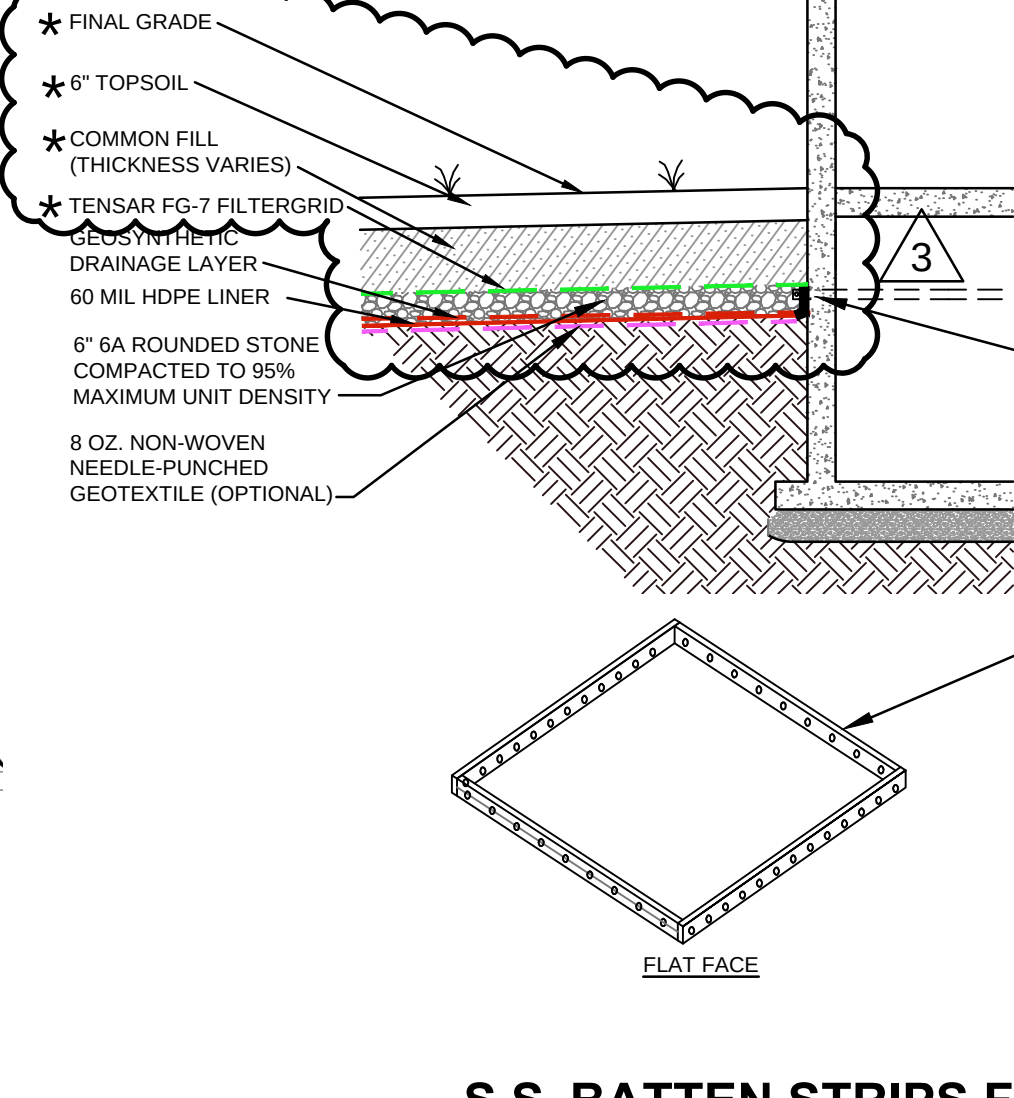
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FIGURE 6
HEAVY CONCRETE PAVING SECTION
SCALE: NOT TO SCALE



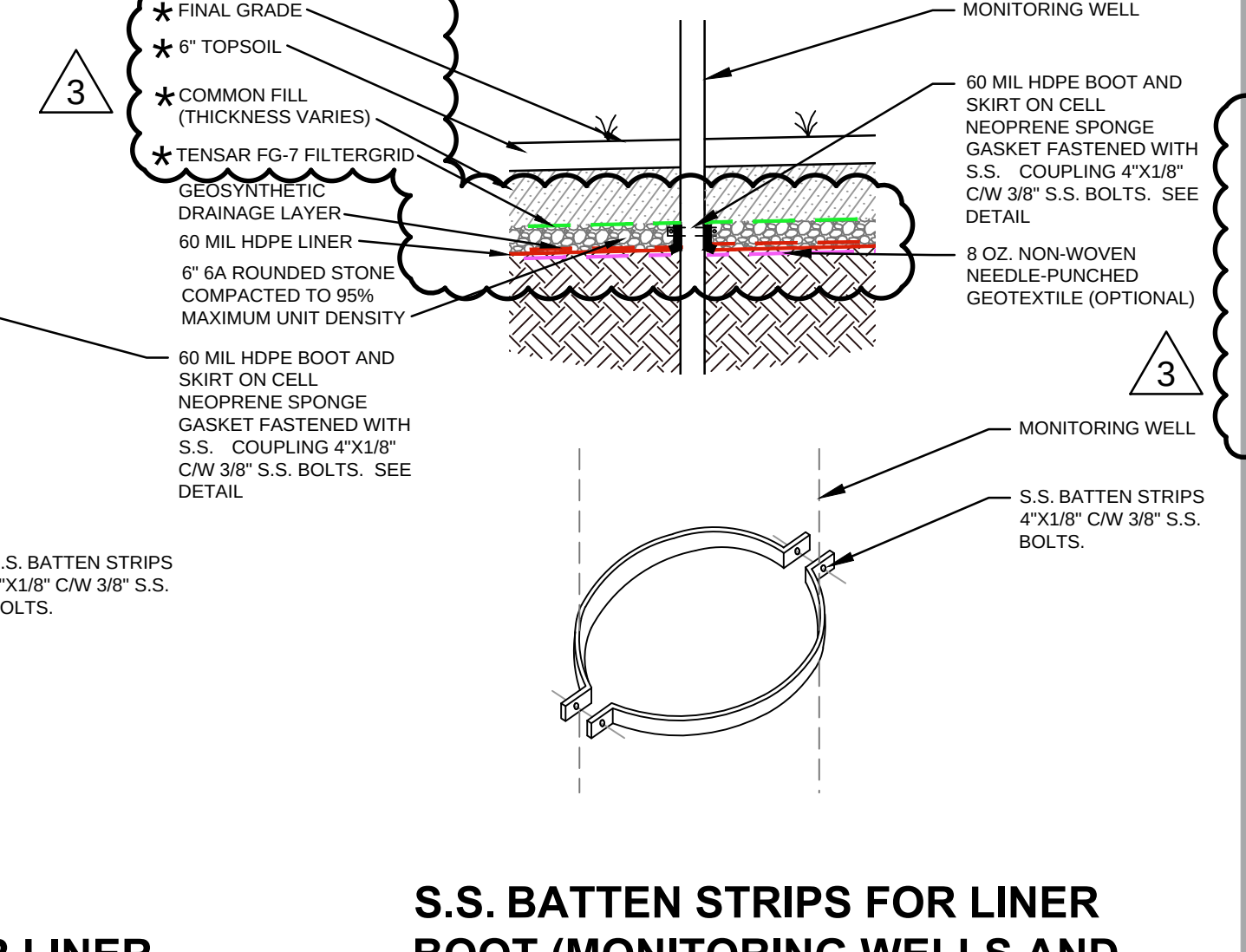
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FIGURE 6
TRANSITION DETAIL
SCALE: NOT TO SCALE



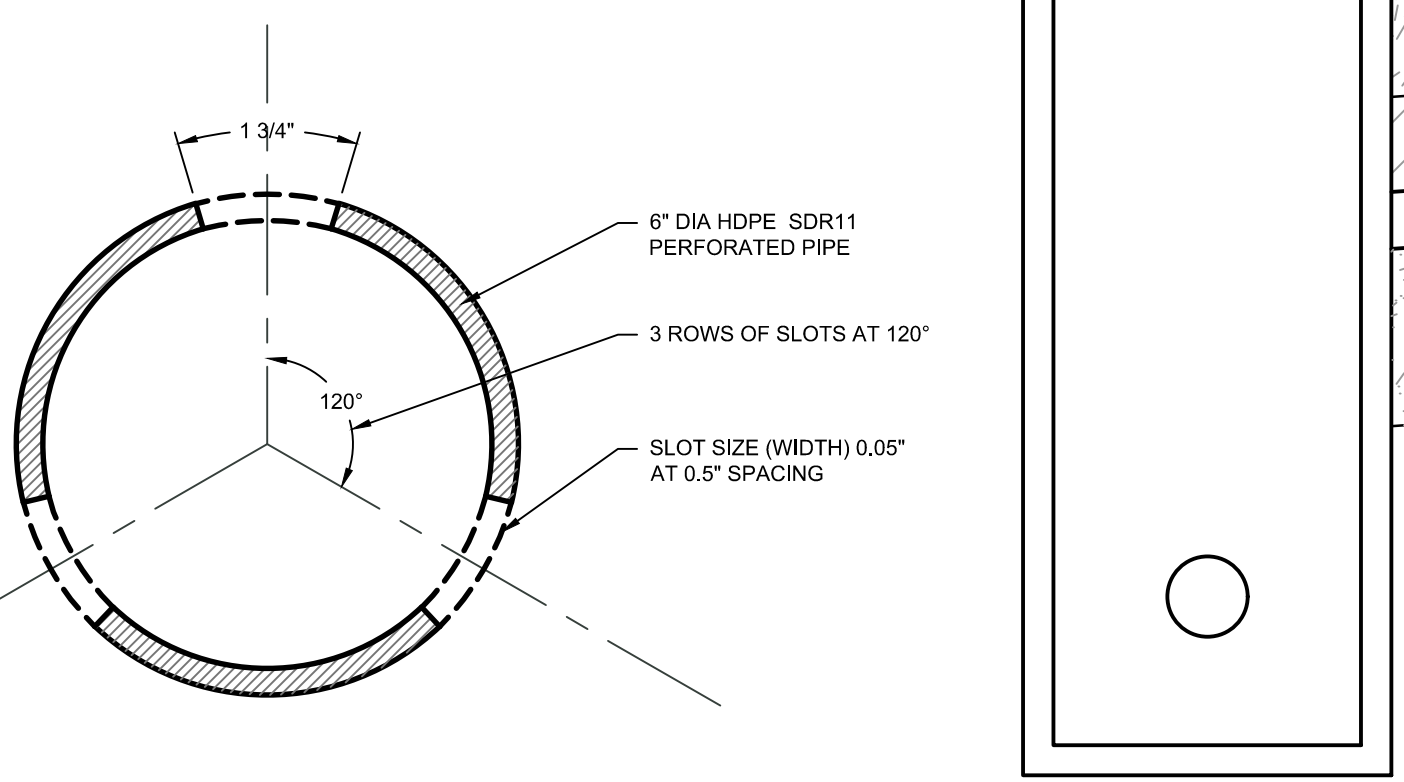
5
FIGURE 6
S.S. BATTEN STRIPS FOR LINER BOOT (FOUNDATION WALL)
SCALE: NOT TO SCALE



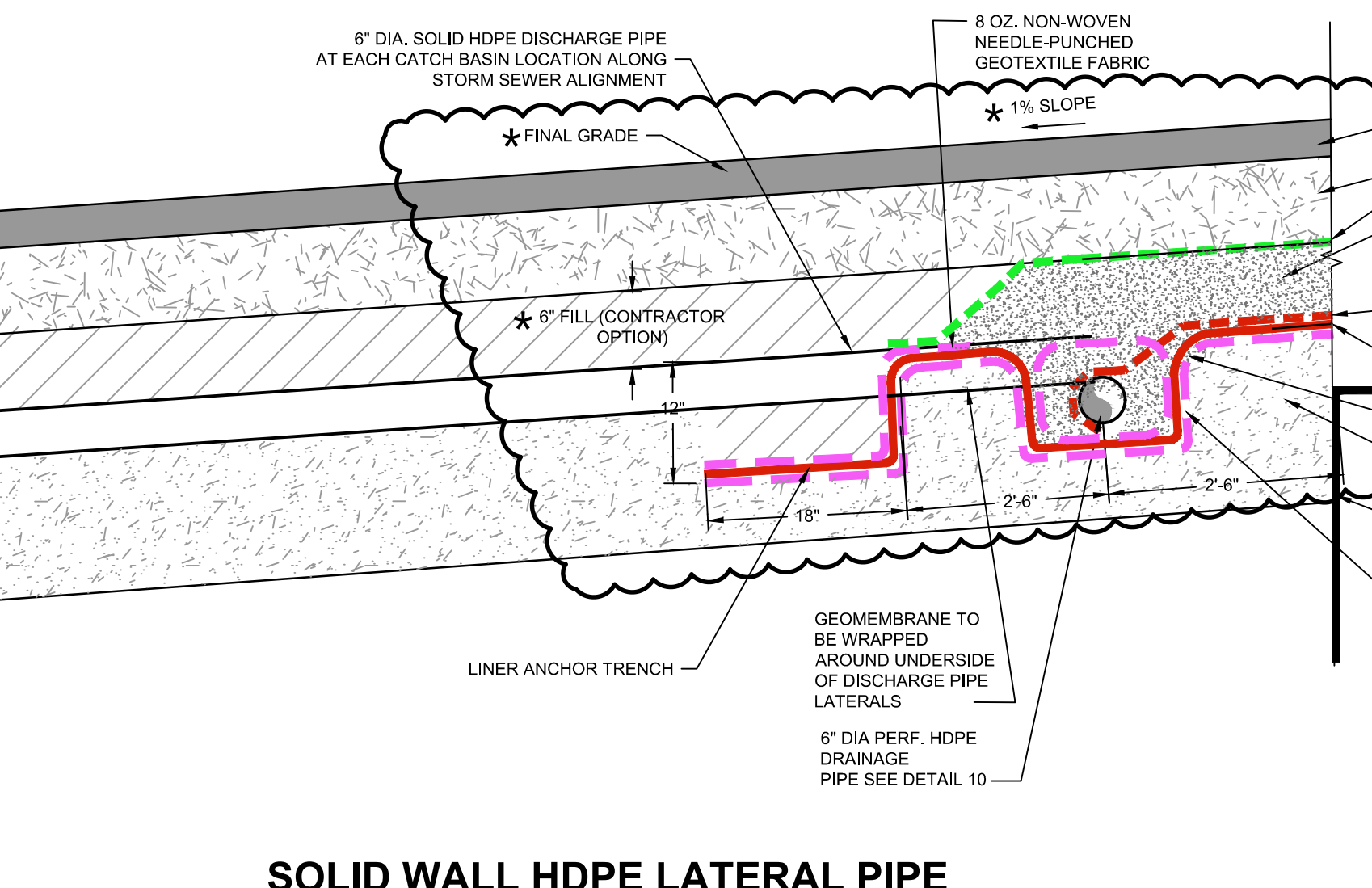
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FIGURE 6
S.S. BATTEN STRIPS FOR LINER BOOT (CONCRETE CHAMBERS)
SCALE: NOT TO SCALE



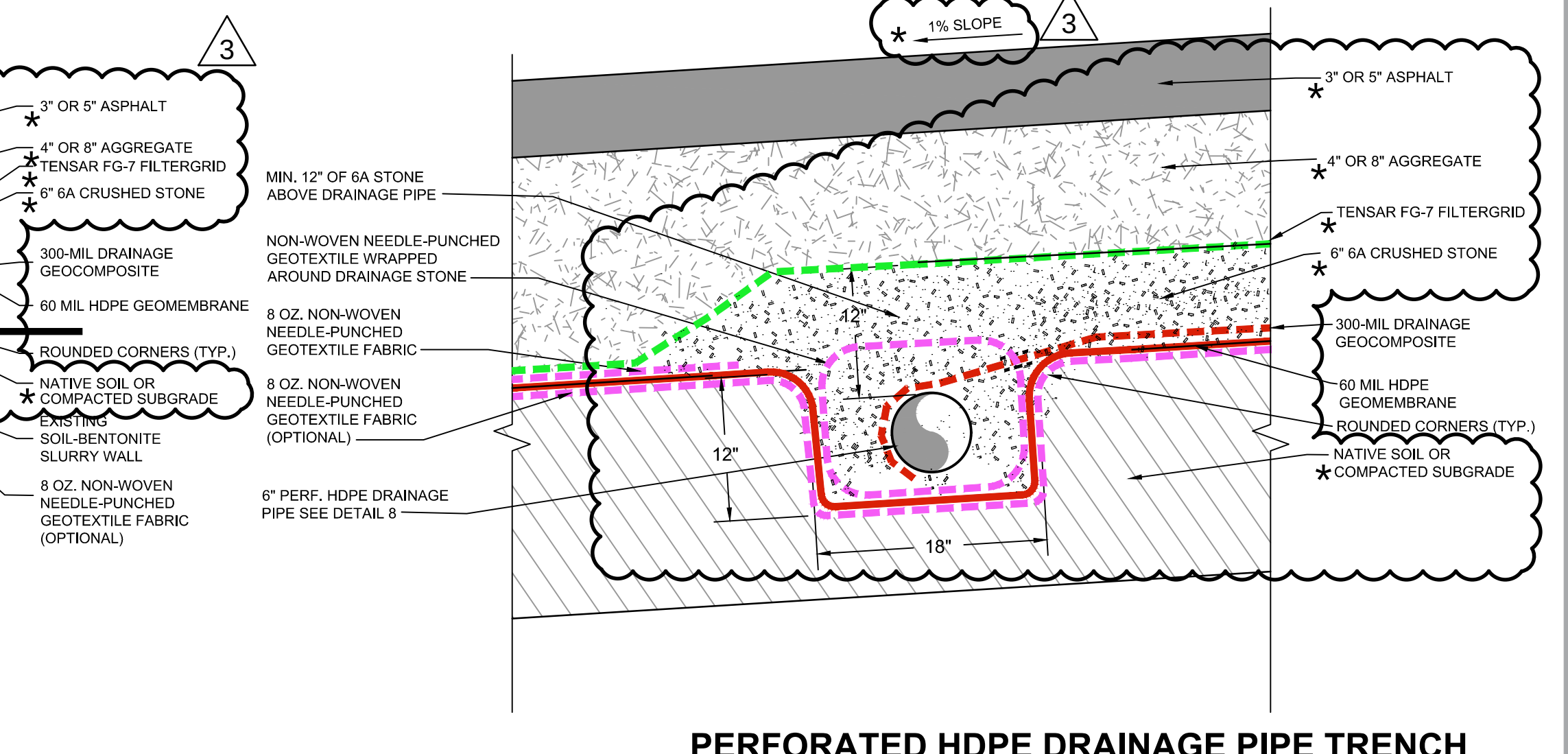
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FIGURE 6
S.S. BATTEN STRIPS FOR LINER BOOT (MONITORING WELLS AND OTHER SMALL ROUND PIPES)
SCALE: NOT TO SCALE



8
FIGURE 6
PIPE PERFORATION DETAIL
SCALE: NOT TO SCALE

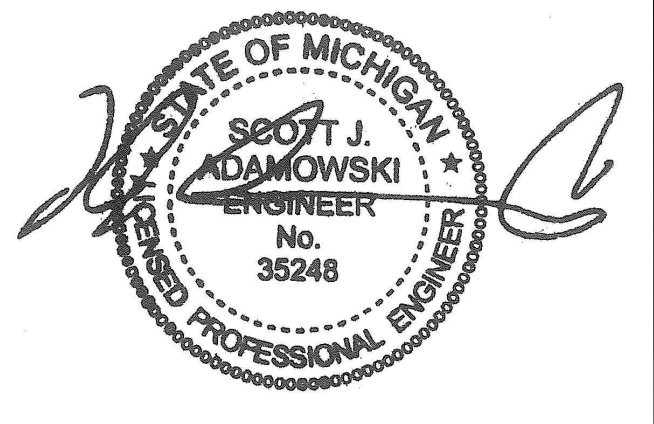


9
FIGURE 6
SOLID WALL HDPE LATERAL PIPE (LIGHT AND HEAVY PAVING SECTIONS)
SCALE: NOT TO SCALE



10
FIGURE 6
PERFORATED HDPE DRAINAGE PIPE TRENCH (LIGHT AND HEAVY PAVING SECTIONS)
SCALE: NOT TO SCALE

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LEGEND

	300-MIL DRAINAGE GEOCOMPOSITE
	60-MIL HDPE GEOMEMBRANE
	8 OZ. NON-WOVEN NEEDLE-PUNCHED GEOTEXTILE (OPTIONAL)
	TENSAR FG-7 FILTERGRID

NOTE:
GHD IS RESPONSIBLE FOR LINER SYSTEM DESIGN ONLY. ALL OTHER COMPONENTS OF THE SITE DEVELOPMENT LIKE BUILDING STRUCTURE, CONCRETE FOOTINGS, ASPHALT AND CONCRETE SURFACE COVER, AGGREGATE SUB-BASE MATERIALS, AND SUB-BASE PREPARATION PERFORMED BY OTHERS. ALL WORK BY OTHERS AND NOT GHD RESPONSIBILITY, AS NOTED BY ASTERISK, IS PRESENTED ON SEPARATE WEBB ENGINEERING DRAWINGS (PROJECT #20.316)

Client
RACER TRUST
Project
**13000 ECKLES ROAD SITE
LIVONIA, MICHIGAN
LINER SYSTEM DESIGN**

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No.	Issue	Drawn	Approved	Date
Drawn	MS	Designer	RH	
Drafting Check	RH	Design Check	SA	
Project Manager	CM	Date	Jul 8, 2021	
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Original Size				AS SHOWN
ANSI D				Bar is one inch on original size drawing

Project No. **012607-01**

Title
DETAILS

Sheet No.

FIGURE 6

Appendix C

Daily Observation Report

DAILY OBSERVATION REPORT

CONTRACT NAME:

PROJECT NO.:

CONTRACT NO.:

CONSULTANT:

CONTRACTOR:

COMPLETED BY: _____

DATE: _____

TIME IN:

TIME OUT:

[illegible]

[illegible]



Contractor:							
Personnel	No.	Hr.	Activity	Equipment	No.	Hr.	Activity
Subcontractor:							
GHD:							



Manufacturer's Rep.							
Personnel	No.	Hr.	Activity	Equipment	No.	Hr.	Activity
Inspecting & Testing (Inspec-Sol)							
Personnel	No.	Hr.	Activity	Equipment	No.	Hr.	Activity
Persons Contacted:				Materials Delivered:			
Items Discussed:							
Requested Revisions or Interpretations:							
Nonconforming Work Reported This Date to CONTRACTOR:							
Comments:							
Visitors:							
Attachments:							



DAILY QUANTITIES/REMARKS/OTHER NOTES:

Location	Work Completed / To Be Paid
Other Notes:	

Acknowledgement Signatures:

CONSULTANT: _____ (PRINT) _____ (SIGN) **Date:** _____

CONTRACTOR: _____ (PRINT) _____ (SIGN) **Date:** _____

Appendix D

Field Record Forms

Site Report

1910005-QA-FRM-08 Rev. 00

PROJECT No.:		DATE:	
CLIENT:		CONTRACTOR:	
PROJECT:		COMPACTION	SUBGRADE EVALUATION
LOCATION:		ROOFING	REINFORCING STEEL
		FOOTING BASE EVALUATION	CONCRETE
		STRUCTURAL STEEL	CONSTRUCTION QA MONITORING
FIELD RESULTS	Temperature:	oF	Weather Conditions:
CORRECTIVE ACTION TO BE TAKEN:			
FOLLOW UP VISIT REQUIRED:			
SITE REP.:		PREPARED BY :	
OF:		REVIEWED BY :	

FO-210.08(On) / IA / 06-13

Date: _____

Weather: _____

Material: _____

PT = Probe Test

[illegible]

Probe Test: PSI

REPAIR TYPES:

C - Cap Strip

P - Patch

DS# - Destruct Sample
EE - Earthwork Eq't Damage
FM - Fish Mouth
ES - Exposed Scrim
D - Damage

WR - Wrinkle
WS - Welder Restart
BL - Blister
T - Joint

B - Extrusion Bead
* TOS - Top of Slope
** EOS - End of Seam

Site Rep:	Prepared By:
Of:	Reviewed By:

CONFIDENTIAL - FOR PROJECT TEAM USE ONLY

Pre-Weld / Destructive Sample Information

Panel Seaming Form

Panel Seaming Form
1910005-QA-FRM-12 Rev. 01

Project Name: _____
 Liner Superintendent: _____
 Reported by: _____

Date: _____
Material: _____

Sampling Frequency every 300m

[illegible]TOTAL SEAM LENGTH Linear Metres

Site Rep:	Prepared By:
Of:	Reviewed By:

1910005-QA-FRM-13 Rev. 01

Date: _____
Weather: _____
Material: _____

[illegible]

Site Rep: _____
Of: _____

Prepared By:
Reviewed By:

Panel Placement Form (Liner)

Panel Placement Form
1910005-QA-FRM-14 Rev. 00

Project Name: _____

Liner Superintendent: _____

Reported by: _____

Date: _____

Weather: _____

Material: _____

Time	Panel Number	Roll Number	Location	Panel Dimensions			QA ID	Comments / Date Covered with Stone
				Length	Width	Area		
TOTAL LINER PLACED:								

Site Rep:	Prepared By:
Of:	Reviewed By:

Panel Placement Form (Geotextile)

Panel Placement Form
1910005-QA-FRM-14 Rev. 00

Project Name: _____

Liner Superintendent: _____

Reported by: _____

Date: _____

Weather: _____

Material: _____

[illegible]

TOTAL LINER PLACED:		
---------------------	--	--

Site Rep:	Prepared By:
Of:	Reviewed By:

GCL Placement Form

Panel Placement Form
1910005-QA-FRM-15 Rev. 00

Project Name: _____
Liner Superintendent: _____
Reported by: _____

Date: _____
Weather: _____
Material: _____

Time	Panel Number	Roll Number	Location	Panel Dimensions			QA ID	Comments
				Length	Width	Area		

TOTAL LINER PLACED:		
---------------------	--	--

Site Rep:	Prepared By:
Of:	Reviewed By:



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→ The Power of Commitment